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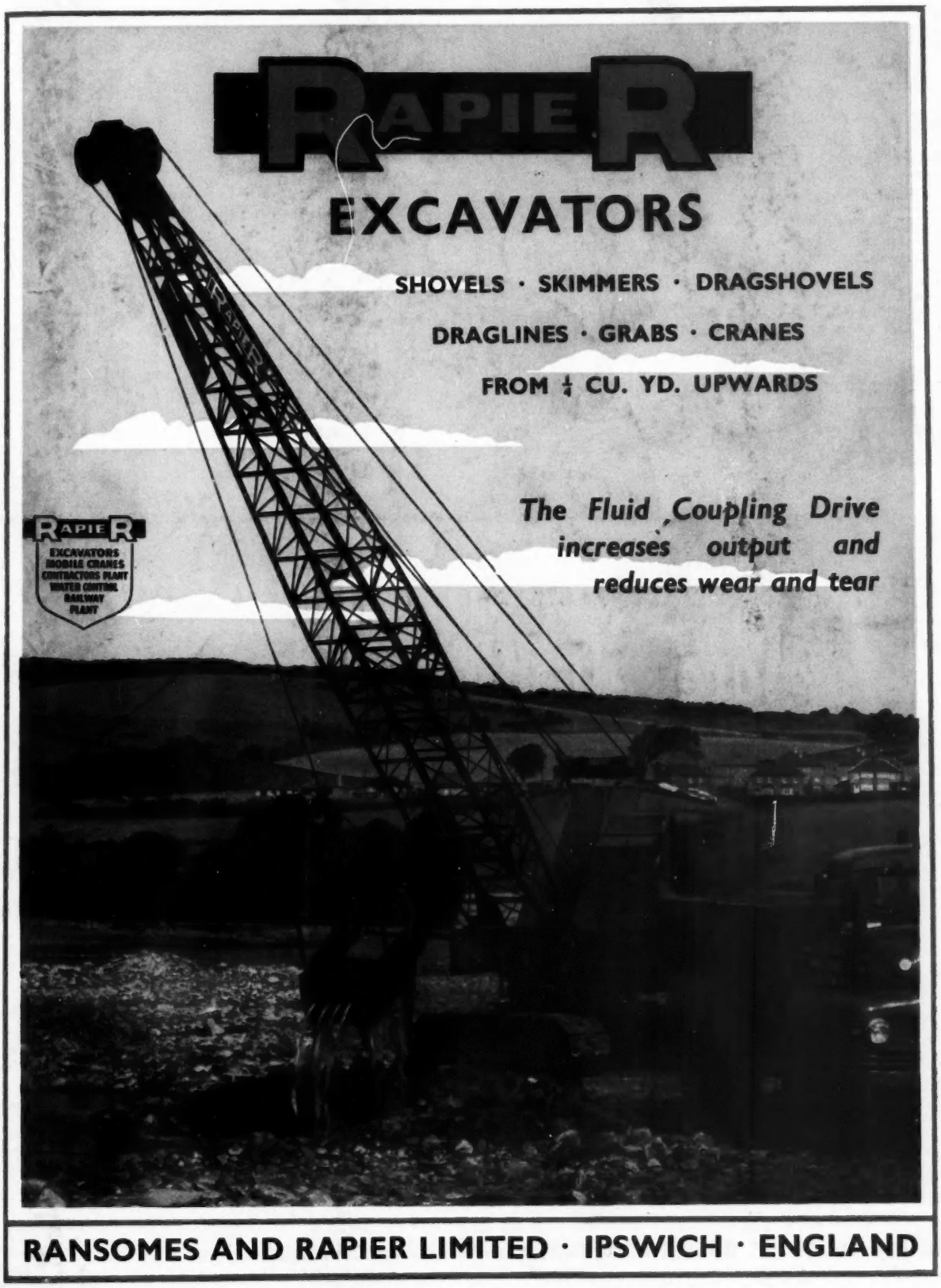

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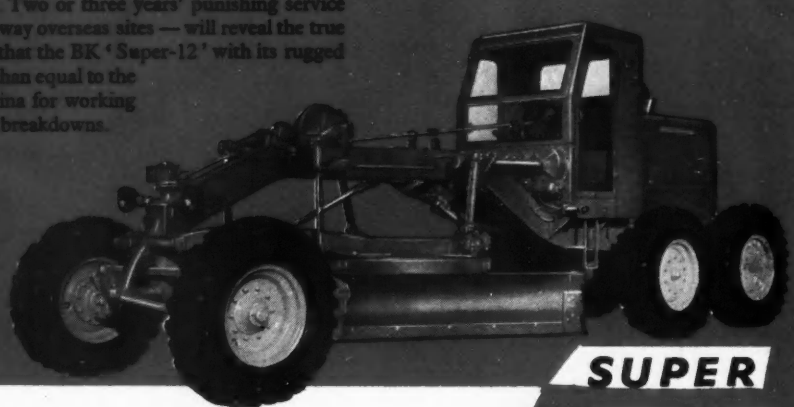

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CONTENTS

LEADING ARTICLE—
Retrospect 1

ARTICLES—
Aeronautics in 1955. (Illus.) 12
Atomic Energy in 1955 9
Civil Engineering in 1955. No. I. (Illus.) 22
Continental Engineering in 1955. No. I. (Illus.) 29
Electrical Engineering in 1955. No. I. (Illus.) 19
National Boat Show 5
Naval Construction in 1955. No. I. (Illus.) 25
New Year Honours 5
Ports Efficiency Committee 5
Royal Navy in 1955. No. I. (Illus.) ... 6
Shipbuilding and Marine Engineering in 1955. No. I. (Illus.) 16
Turbine Airliners Enter B.O.A.C. ... 5
100 Years Ago 5

AMERICAN SECTION—
Power from Niagara Falls 34
American Water Power Schemes in 1955. (Illus.) 34

OBITUARY—
Sir Richard Redmayne, K.C.B. 4

NEWS AND NOTES—
Books of Reference 18
British Patent Specifications. (Illus.) ... 39
Calendars and Diaries 40
Forthcoming Engagements 40
Industrial and Labour Notes 33
Personal and Business 38

SIXTEEN ART PLATES—
British Atomic Power Projects
Power Stations of 1955 (External Views)
Power Stations of 1955 (Internal Views)
Oil Tankers of 1955
Cargo-Passenger Ships of 1955
British-Built Steam Locomotives of 1955
Diesel-Electric and Electric Locomotives of 1955
Automobile Engineering in 1955
Water Supply Schemes of 1955
Military Aircraft of 1955
Civil Aircraft of 1955
Progress of New Collieries in 1955
Civil Engineering in 1955
United States Gas Turbines in 1955
Large Bucket Excavator for a German Lignite Mine
Machine Tool " Automation " in the United States in 1955

RETROSPECT

Seldom have any year's events cast shadows before them so strongly as those of 1955. Of that year more obviously than of any year since the war it could be seen that

> " There is a history in all men's lives
> Figuring the nature of the times deceas'd,
> The which observed, a man may prophesy
> With a near aim, of the main chance of things
> As yet not come to life which in their seeds
> And weak beginnings lie interred."

In the last months of the war and in the months that followed we grew used to the publication of this or that " Plan " for rebuilding and modernising cities, transport, industrial production, and the like. It seemed at that time to occur to no man to add up the total cost in man-hours of doing all the things that it was planned should be done and to equate the result to the man-hours likely to be available and to the resources in technical skill that could be counted upon. Wars breed that kind of optimism. Poverty stricken men dream of riches. Wracked by the miseries of war, they visualise a land fit for heroes to live in. Many of the more vaguely worded " plans " of the immediate post-war era have proved to be such dreams ; dreams of what men would like to do rather than of things that could be done within a lifetime. By contrast 1955 was a year notable for the publication of plans carefully judged in relation to resources, practicable plans that really can be realised and for the most part plans upon the realisation of which a start was actually made. Thick and fast in the early months of the year those plans were published.

RAILWAY PLANS

First came the plan of the British Transport Commission. It was published in January and proved to be more exciting and to foreshadow more wholesale changes than the public had expected. Within fifteen years there is to be an expenditure of some £1200 million upon railway modernisation. Two main lines, King's Cross to Doncaster, Leeds and, possibly, York, and Euston to Birmingham, Crewe, Liverpool and Manchester are to be electrified. As from next year no new steam locomotives are to be built. Motive power for lines not electrified is to be provided by diesels, of which some 2500 will be built. Main line speeds are commonly to reach 100 m.p.h. There will be substantial improvements of track and of signalling, including a much more extensive use of colour-light signals. There are to be many more continuously braked freight trains. Detail still remains to be worked out. A decision, for example, was not reached in 1955 upon the system of electrification to be employed. But that the Commission was in earnest in putting forward its plan was revealed later in the year by the placing of firm orders for 141 diesel locomotives and thirty power units, and by inquiries, some tentative, some firmer, received by a variety of manufacturers for electrical, signalling and other equipment. So wholesale a modernisation of the railways extending, it may confidently be prophesied, into years well beyond the limits of the present plan, must prove an exciting prospect for youth and attractive to young men of ability to enter railway service.

ROAD CONSTRUCTION

In February the Government, which had in the previous year been slowly relaxing, under a growing weight of criticism, from its formerly firm and altogether short-sighted attitude, that barely enough even for maintenance could be afforded on the roads, relented still further. It was announced that a sum amounting to about £147 millions would be " approved " for expenditure upon road improvements within four years ; and that that sum did not include the cost of any work upon motorways. That, despite the equivocal nature of this announcement, the Government may at last be in earnest, was suggested by the fact that a detailed list of roads affected accompanied the announcement, that work was begun in some places during the year and that work preparatory to the beginning of the construction of a motorway eventually to connect London with

Birmingham and Yorkshire was put in hand. Welcome, however, though this activity proved to be, criticism of the Government did not cease. For, relatively to the real need, the sum to be expended annually is woefully small. Many of those affected by transport delays were led by the frustration of their hopes to advocate that expenditure on road construction should be freed from Treasury control and that some body independent of the Government and perhaps analogous to the Board of a nationalised industry should be set up with an income guaranteed from motor taxation to plan and construct the nation's roads. Yet the Government's plans seemed more definite than any announced since the war. Better that action should be " too little and too late " than that there should be none at all !

But if there is an urgent need for the construction of new highways between cities, there is an even more clamant need to relieve congestion within cities. There the Government's proposals, announced during 1955, were totally inadequate. The removal, for example, of the Notting Hill Gate bottleneck in London, the widening of a short length of the Strand, the improvement of Hyde Park Corner, and even the extension of the Cromwell Road (without, it is to be observed, sadly needed fly-overs) can do, in relation to the widespread congestion, effectively very little to relieve a situation which within a year or two literally threatens to bring London's traffic to a standstill in every rush hour. Some time—and it must be within a very few years—we look forward to welcoming in a Retrospect the starting of work upon a very costly but essential scheme for bringing a high-speed double-track highway from the outside right into and through or around London's centre and the putting in hand of similar urban highways elsewhere. *Force majeure* has made such highways essential in many American cities ; it will do so here. The sooner a start is made the more cheaply they will be constructed.

Nuclear Energy

In the same month, February, there came an announcement about the development of nuclear energy. It proved to be an exciting surprise. For few men outside the United Kingdom Atomic Energy Authority—which had itself been set up only about six months earlier—were fully aware to what an extent the sheer engineering problems of building nuclear power stations had been solved or realised how cheaply power from the atom could be generated. It is, of course, true that there is at present an element of unreality in estimating the cost of power sent out from a nuclear power station. For the price at which the plutonium produced as a by-product can be sold has a large bearing upon the result, and only the Government can fix the price. Yet the price of coal has been rising ever since the war and we find it difficult to conceive that it will not continue to rise in the future. The higher the cost of coal, the more economic the development of nuclear energy becomes comparatively to thermal power. Moreover, even if the Coal Board, which was reorganised in February, does eventually manage to raise coal output to some 250 million tons a year as contemplated in the Coal Plan, there can be very little doubt that demands for fuel will have gone by then even higher. The possibility of generating nuclear power economically has come only just in time to prevent Britain becoming, at a high cost in foreign exchange, a substantial coal importer.

The programme for the construction of nuclear power stations announced in February proved to be flexible. Besides Calder Hall, which this year will become the first full-scale station in the world to generate nuclear power for public supply, the construction of two gas-cooled graphite-moderated stations of the Calder Hall type is to be started about 1957 and work upon two further similar stations is to be started about eighteen months later. The total output of these four stations, the sites for two of which have already been selected, should amount to something between 400MW and 800MW and they should all be in operation by 1963. Thus far the plan is definite enough. The rest must be regarded as conjectural rather than definite and it depends no doubt in part on the rate of technical advance achieved by interested industrial firms. The plan suggests, rather than lays down, that the construction of four more stations might be begun in 1960 and a further four in 1961 or 1962. But what kind of station could be built by that date cannot be specified. Plutonium from the early reactors should begin to become available in the mid 'sixties at the rate of several hundred kilograms per year, making possible the enrichment of fuel charges in later, probably liquid-cooled, reactors and the rapid expansion thereafter in supplies of plutonium would make possible much larger subsequent programmes of nuclear power plant construction. Subsequently the Government announced that four more stations would be erected at an early date mainly to supply plutonium. The consequent increased rate of plutonium production may possibly permit an acceleration of the programme for nuclear power plants for public supply.

With these plans in front of them industrial firms showed a suddenly awakened and vigorous interest in the possibilities of nuclear power ; and they hastened to form themselves into groups each capable of undertaking the whole of the work necessary in designing and constructing power plants. This active interest was further invigorated by the holding of an international conference and exhibition on peaceful uses of atomic energy at Geneva in August, at which many matters hitherto shrouded in secrecy were revealed and an immense stimulus was provided not only for further research but, competitively, for firms to study the possibilities of exporting power plants, instruments, gear and equipment.

Other Plans

In March there came news of the revised plans of the Iron and Steel Board, designed to raise steel production in this country to 22½ million ingot tons annually by 1958 instead of 21,000,000 tons as originally proposed in 1953. Steel users may, indeed, have doubts about the adequacy of that target output to meet demands. But despite disturbances consequent upon nationalisation and denationalisation, the performance of the industry since the war has been very fine. Output has been raised from 12,695,000 tons in 1946 to well over 20,000,000 tons in 1955. Though often by only a narrow margin the industry has on the whole managed to keep output about level with demand. No doubt it already has plans on paper further to expand output beyond 1958. For to judge by the average rate of increase in the usage of steel since 1948 an output of some 28,000,000 tons will be needed early in the next decade.

One other plan deserves brief mention as casting a longer shadow into the future than any other so far mentioned. It was announced in the United States that as part of that country's contribution to the scientific work of the International Geophysical Year, 1957, an artificial satellite would be set up to follow an orbit around the earth.

Automation

So much for plans ; but there were other developments in 1955 which threw sharply etched shadows across the future. One was a relatively sudden widening of appreciation amongst engineers of the direction in which the evolution of production methods is trending. A new word from across the Atlantic began commonly to be used by engineers—automation. And the Institution of Production Engineers even deemed the time ripe to organise a conference on the automatic factory. There is, of course, nothing really new about automation. The automatic transfer of the medium being worked upon from one station to another is common in the oil and chemical industries and automatic control of the processes carried out is normal. Gases and liquids, of course, lend themselves to automatic processing. But in the steel industry there is already a great deal of automation ; and elsewhere individual examples of it can be quoted, as, for example, in the manufacture of electric lamp bulbs. Nevertheless, the word has a particular meaning for production en-

gineers. It relates to a further evolution of the mass production process, whereby handling is eliminated, the workpiece passes automatically from station to station, and the gauging and measuring and the readjustment of tools is carried out automatically. The conception could never have been realised as soon as it now promises to be were it not for the advent of electronic devices. It promises to raise productivity per man-hour to unexampled levels; and it has the attraction that it demands for success a much higher proportion of skilled labour on the factory floor than does mass production. Problems in human relations; and problems also of providing a sufficiently high proportion of skilled labour are involved. Members of trade unions not unnaturally fear that a rapid extension of automation would lead to unemployment. But fortunately the evolution is likely to take place gradually.

Education

But to carry out all those plans and others visualised by but not published by independent firms, authorities and the like; to carry out researches essential if this country's products are to compete in efficiency, reliability and cost with those of other nations; to study more fundamental problems like, for example, that of the fatigue of metals, which was thrown into prominence by the report issued in March on the accidents to "Comet I" aircraft; unexampled demands have arisen for fully trained engineers. Where are they to come from? That the problem exists has been fully appreciated ever since the war. More clearly than ever it was seen in 1955 to be rooted in the schools. Too small a proportion of boys are having their attention directed to the opportunities in technology, as against those in pure science or the arts, to lead a full and interesting life. It is, of course, appreciated that a greater number of places must be available for students in universities and much work continued during the year towards the expansion of engineering faculties and towards enlarging and equipping colleges closely linked to universities. But for long it has also been appreciated that the other route to professional qualification through a technical college education needs expansion, too. There the major engineering institutions favoured the concentration of Government expenditure upon a limited number of selected colleges, holding that in that way only could colleges be adequately staffed and equipped to educate students to high standards. But during the year the Government decided otherwise. Following the advice of the National Advisory Council for Education in Industry and Commerce, it reverted in essentials to the scheme first put up by the Labour Government some years ago for an award or awards open to students in all colleges. Perhaps it was inevitable that it should make that choice. For the institutions' proposal was bound to be repugnant to a Council heavily representative of local education authorities who could hardly be expected happily to pick and choose amongst colleges represented in an attempt to decide which should be specially favoured. The institutions accepted the situation with good grace in the hope that evolution would be towards the concentration of effort upon certain colleges which gained particularly high reputations.

Economics and Labour

With the one exception of 1953 this country has experienced balance of payments difficulties in every odd year since the war. Fortunately, that of 1955 was less extreme than its forerunners and various actions taken by the Government seem already to be setting the situation to rights. Yet whatever economists may say, the rightness of applying a credit squeeze as a corrective can be challenged. For its effect inevitably is to operate against capital expenditure: that is, to threaten the early carrying out of the plans discussed above. But it merely needs a little common sense to see that a nation which devotes a high proportion of its productive capacity to the making of capital goods must more rapidly increase its standard of living than one which does not. The symptoms of inflation need to be attacked rather by reducing the demand for consumption goods than by the diversion of effort away from the making of capital goods. There, however, as so often in the study of economics, human nature needs to be taken into account. If taxes are raised in order to reduce purchasing power (as the Chancellor raised purchase tax in his Autumn Budget) wage earners are likely to demand increased earnings more than sufficient to compensate for the change! Indeed, in these days, however much it may be argued that it is the duty of a Government to keep a currency stable by equating purchasing power to the production rate, control is not wholly in Governmental hands. A high responsibility lies in the hands of trade union leaders who, by such a failure to exercise restraint as was witnessed towards the end of 1955 (wage claims pending as the year ended amounted to about £500 million annually), can make nonsense of governmental policy and can very seriously hamper the carrying out of such great plans for the future as are mentioned earlier in this Retrospect. It may, indeed, be significant that all those plans were published in the early months of the year before balance of payments difficulties had made themselves apparent and none in the autumn when the inflationary situation was more fully recognised. It is, of course, possible that a nation's savings—and those made for it in the form of Budget surpluses—can never be expected to equate to the cost of capital expenditure; that, in fact, a high level of capital expenditure in an expanding economy combined with full employment is not compatible with a stable currency. A general trend over the centuries for the purchasing power of money to fall suggests it. But that general trend is very different from the runaway and "vicious spiral" that lack of restraint in wage claims could easily bring about to-day.

Conclusion

Two days ago THE ENGINEER celebrated a rather special birthday—its hundredth. There is, of course, something spurious about selecting a particular age for a special celebration, just as it is absurd to hope for better things in the next twelvemonth, at this season of the year, just because a digit in the date has altered. Yet we confess we find it exciting to have reached 100 years of age. There is a sense of achievement about it lacking in any lesser term of years like ninety-eight or ninety-nine. THE ENGINEER has been published for all that length of time through years of war, through years of prosperity and years of depression. Immense changes have come about; the field it covers has enormously widened. Yet it is as youthfully vigorous and resilient as when it was first started in 1856. We can justly feel that, to have survived so long with so high a reputation, the journal really does serve a high purpose for engineers.

Particularly do we feel that sense of achievement strong within us because we know that our eyes are set not on the past, but on the future. Age with us is not decay. "It is the ripening, the swelling, of the fresh life within that withers and bursts the husk." And how exciting the future looms! It may be, now that the secrets of the structure of the atom are being revealed, that there are no other such fundamental discoveries in science still to be made. We cannot know. It is probable that in research a law of diminishing returns operates so that in proportion to the advances made a greater and greater effort has to be applied to go still further. But how enormous still is the field for the application of engineering knowledge! In relation to the possibilities opening ahead man has, indeed, hardly begun to apply his knowledge. As we look forward, not back, we feel a rich excitement to seize the opportunities that lie before us, and we feel that 100 years of experience, short though that period really is, has given us some measure of maturity so that we shall be able to comment with good judgment upon the actions of the future and report accurately and with a due sense of their relative importance the events of the next hundred years.

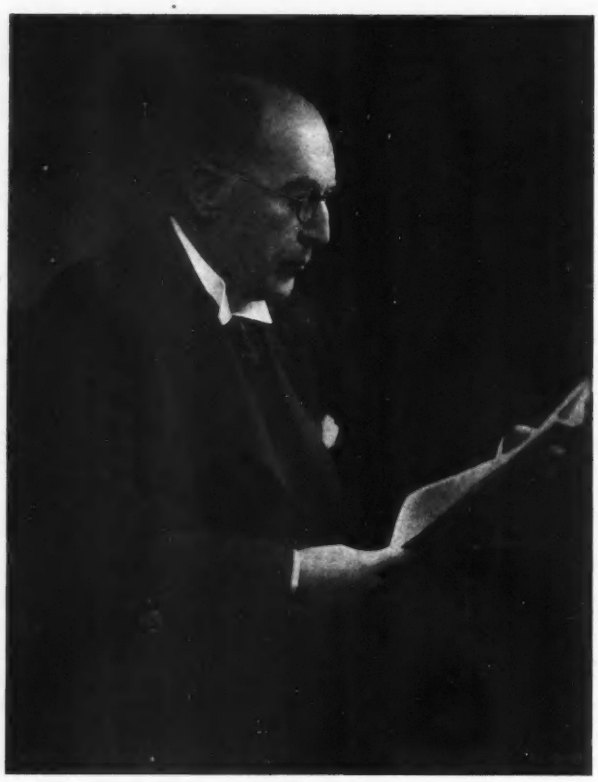
Obituary

SIR RICHARD REDMAYNE, K.C.B.

JUST after our last issue had gone to press, we learned with deep regret of the death of Sir Richard Redmayne, which occurred at his home at Little Hadham, Herts, on December 27th. Sir Richard, who was in his ninety-first year, had an eminent place in the profession of mining engineering. He was an authority on all aspects of coal mining and colliery operation, and until three or four years ago was practising as a consultant. It could not be said that Sir Richard had retired ; in recent times, in his increasing age, he had reduced his activities, but to the end he maintained a lively interest in all the affairs of his profession. He kept himself informed of every development and trend in present-day coal mining, as is evidenced by an article—undoubtedly the last from his facile pen—on "Coal in 1955," which will appear as part of our annual review. Our personal regret at his death is mingled with a measure of pride as we recall that, a few weeks ago, Sir Richard readily agreed to prepare the review of the coal mining industry which he had regularly contributed to our columns for many years past.

Richard Augustine Studdert Redmayne, who was the fourth son of the late John Marriner Redmayne, was born at Low Fell, Co. Durham, in 1865. He studied at the Durham College of Science, and in 1883 entered the Hetton Collieries as an apprentice. In his autobiography, *Men, Mines and Memories*, Sir Richard commented that in his day the training of a mining apprentice was severe! His chief, he said, was a strict disciplinarian and hard task-master, insisting on his young apprentices learning "by actual participation therein most of the practical work carried on in the mine." At one period of his apprenticeship, Sir Richard recorded, he used to rise daily at 2.30 a.m., walk to the mine a mile and a half away, descend at 3.30 a.m. with the fore-shift deputies, and remain underground, travelling the workings, until 10.30 a.m. In the afternoon, he was required to attend the office in order to write a report on his underground work and to do other administrative work ! When his apprenticeship was over, Sir Richard remained at Hetton as an under manager. Altogether, he spent eight and a half years there. It was at Hetton that Sir Richard first experienced, in December 1886, a colliery explosion ; in the subsequent years of his career he took a prominent part in the progress of safety in mines.

Sir Richard left Hetton in 1891 to go to South Africa, where for the next two years he was engaged in mine management in Natal, and in surveying mining properties. He returned to this country in 1893 and became resident manager at the Seaton Delaval collieries in Northumberland. Sir Richard lived and worked at Seaton Delaval for just over nine years, and then, in March, 1902, he was appointed to the chair of mining in the then recently established University of Birmingham. As a preliminary to that appointment, Sir Richard spent some months in Canada and the U.S.A. to see what was being done in mining schools there. The equipment and efficiency of those schools, he reported, impressed him greatly. Sir Richard's work at Birmingham University—of which Sir Oliver Lodge was then the principal—continued for six years. His curriculum for the mining school was devised to give a thorough grounding in the principles of pure science during the first two years of the course, the third year being devoted to the application of the scientific knowledge acquired. During his years at Birmingham University, Sir Richard was able to engage in consulting work, and he also served on two important Government committees. The first of them was the Eight Hours Committee, set up "to inquire into the probable economic effect of a limit of eight hours to the working day of coal-miners." The other committee was one set up, early in 1908, by the Royal Commission on Accidents in Mines, "to visit and inspect representative collieries in different parts of the United Kingdom and to make inquiries into the causes of and means to prevent accidents from falls of ground, underground haulage, and in shafts." Sir Richard was appointed chairman of the committee and said himself, many years later, that its work formed one of the most interesting investigations with which he was ever concerned.



Sir Richard Redmayne

At about the same time, Sir Richard was appointed by the Home Secretary to hold a formal investigation into a disaster at the Hamstead Colliery, near Birmingham. This disaster was a fire at the bottom of the downcast shaft, the initiating cause being the ignition of a large case of candles kept there for supplying the miners with their daily ration on going to work. Undoubtedly, Sir Richard's services on these two committees and in the Hamstead investigation led the Home Secretary of the day to invite him, in the spring of 1908, to occupy the newly created office of Chief Inspector of Mines. At first, Sir Richard demurred ; he was not anxious to leave the school which he had so successfully established at Birmingham University, nor to relinquish the consulting work he was able to do. But the Home Secretary made a second approach to him, and later in 1908 he began his duties as Chief Inspector of Mines, an appointment in which he certainly enhanced the reputation which he had already gained. Already, there was in mind the preparation of the Parliamentary Bill which subsequently became the Mines Regulation Act of 1911. Sir Richard's experience contributed in no small measure to the framing of that Act. He occupied the office of Chief Inspector of Mines for twelve years, in which time, to quote his own words, "there occurred some of the greatest colliery disasters in the history of British mining." All of them were subjected to the most thorough investigation by Sir Richard ; his detailed reports on those investigations and on many aspects of mining practice never failed to recommend measures which could be taken to improve safety in mine operation. We have before us as we write a list, prepared by Sir Richard himself at our invitation a few years ago, of the reports which he compiled during his years as professor of mining at Birmingham and during his tenure of the Chief Inspector's office. It is a formidable document, but it emphasises the breadth of his expert knowledge and the meticulous care with which he carried out all his duties. The first world war—just prior to which he was created K.C.B.—added considerably to Sir Richard's responsibilities.

In 1918, Sir Richard was appointed chairman of the Imperial Mineral Resources Bureau, and two years later he resigned his position as Chief Inspector of Mines. Thereafter, he resumed his work as a consulting mining and civil engineer. In this period as a consultant he was frequently called upon for services to the Government. In this connection, his evidence before the Samuel Commission in 1925 and before the subsequent Royal Commission on Subsidence from Mining carried considerable weight in the formulation of the reports of those bodies. Nor will Sir Richard's many services to the professional Institutions be quickly forgotten. He was a past-president of the Institution of Civil Engineers and of the Institution of Mining and Metallurgy, a member of the Institution of Mining Engineers, and a Fellow of the Geological Society. In addition, from the time of its formation in 1922 up till his death, Sir Richard was president of the Institution of Professional Civil Servants ; its work was one of his special interests. In the performance of all his duties, Sir Richard not only gave readily of his outstanding technical ability, but he also displayed a kindly and thoughtful character which could not fail to impress all who were privileged to know him.

A Seven Day Journal

New Year Honours

THE list of New Year Honours to be conferred by Her Majesty The Queen was published last Monday morning. The list notifies honours awarded to a number of engineers, scientists and industrialists. Among them are the following: Baron—Sir Frederick Godber, chairman of Shell Transport and Trading Company, Ltd.; Baronet—Sir Hubert Houldsworth, chairman of the National Coal Board; Knights Bachelor—Mr. Charles Connell, chairman of Charles Connell and Co., Ltd.; Mr. L. E. Ford, general manager, Port of London Authority; Mr. H. F. Harding Jones, deputy chairman of the Gas Council; Brigadier A. H. Killick, secretary, Royal Institution of Chartered Surveyors; Mr. W. Lyons, chairman and managing director of Jaguar Cars, Ltd.; Mr. G. M. McNaughton, chief engineer, Ministry of Housing and Local Government; Professor A. G. Pugsley, M.I.C.E., University of Bristol; Professor Solly Zuckerman, deputy chairman, Advisory Council on Scientific Policy, and Mr. T. A. W. Foy, lately chief engineer, Lower Sind Barrage. In the Order of the Bath, Sir Frederick Brundrett, scientific adviser to the Minister of Defence, receives the K.C.B., and the following become C.B.: Mr. W. Cawood, principal director of scientific research (air), Ministry of Supply; Mr. W. C. M. Couch, deputy director of electrical engineering, Admiralty; Air Commodore W. E. G. Mann, director-general of navigational services (civil aviation), Ministry of Transport; Mr. W. J. Richards, director, Radar Research Establishment, Ministry of Supply. In the Order of St. Michael and St. George, the following are created C.M.G.: Mr. E. R. Wilkinson, commercial manager, Central Electricity Authority; Mr. O. H. Woodward, for services to mining and metallurgy, and Mr. C. T. F. Serjeant, lately deputy general manager, Sudan Railways. In the Order of the British Empire, Sir John Morison, chairman of the Iron and Steel Holding and Realisation Agency, becomes G.B.E., and the honour of K.B.E. goes to Sir Hugh Beaver, M.I.C.E., for his services to industry, and to Sir Claude Gibb, F.R.S., chairman and managing director of C. A. Parsons and Co., Ltd. The following are made C.B.E.: Captain C. F. Booth, assistant engineer-in-chief, General Post Office; Mr. W. H. Cashmore, director, National Institute of Agricultural Engineering; Mr. S. H. Clarke, director, Fire Research Station, D.S.I.R.; Mr. H. V. Disney, chief engineer, Industrial Group Headquarters, U.K. Atomic Energy Authority; Mr. A. T. Doodson, director, Liverpool Observatory and Tidal Institute; Mr. Robert Graham, director of aircraft research and development, Ministry of Supply; Mr. H. V. Hayes, director of air technical publications, Ministry of Supply; Mr. H. F. Hodgson, managing director of Joseph Sankey and Sons, Ltd.; Captain W. M. Hutchison, chief marine superintendent, British Tanker Company, Ltd.; Mr. Harry Richardson, principal of Bradford Technical College; Mr. T. A. Rogers, deputy chief inspector of mines and quarries, Ministry of Fuel and Power; Mr. R. S. Stafford, technical director of Handley Page, Ltd.; Mr. Gerald Steel, general managing director of The United Steel Companies, Ltd., and Mr. J. G. Taylor, N.E. divisional road engineer, Ministry of Transport.

National Boat Show

AT 11 o'clock on the morning of Thursday, December 29th, the second National Boat Show, which is organised by the Ship and Boat Builders' National Federation and sponsored by the *Daily Express*, was opened in the Empire Hall at Olympia, London. The ceremony was performed by Mr. J. Stapleton, the lighthouse-keeper from the Fastnet Rock, which is the turning point of the 600-mile Fastnet race. He rang "Full Speed Ahead" on a ship's telegraph to indicate that the show was open. This year's show is almost twice the size of the previous year's and about 160 exhibitors display everything connected with boat-building and associated services. The items on view include large and small sailing yachts and motor cruisers, a variety of runabouts, numerous powered and sailing dinghies, canoes and folding boats, ancillary equipment ranging from life-saving appliances to binnacles and engines of both small and large horsepower. As last year, there is an old boat on view and this is a six-oared Newquay pilot which has a length of 30ft by 4ft 11in beam and was built of Cornish elm at St. Mawes, Cornwall, in 1820, and is stated to be the oldest boat still in use. The boat, which is owned by the Newquay Rowing Club, is contrasted with the racing eight in which Cambridge set up the record of 17 minutes 50 seconds for the University Boat Race in 1948. Wood, the traditional boat-building material, is well represented, often in the form of moulded plywood, while a number of craft are built of aluminium alloy or of glass fibre, examples of the use of the latter material being a 24ft lifeboat and a 26ft launch. As last year, there is an active "build-it-yourself" boatyard and also a section exhibiting craft having a maximum price of £250. Among the items of particular interest are the 8-ton sloop "Wanderer III," which recently completed a round-the-world cruise, the sand yacht "Coronation Year Mark II," and a detailed scale model of the "Mayflower," in which the Pilgrim Fathers sailed to America in 1620, and of which a full-scale replica is being built at Brixham in preparation for setting sail to America on Independence Day.

100 YEARS AGO

("*THE ENGINEER*," *JANUARY* 4, 1856)

THE MECHANICAL PHILOSOPHY OF RAILWAYS

"We prate from time to time of the marvels of our age, and assume that things are perfect because they are less imperfect than things that went before them, *quoad* their utility; but we forget to inquire whether they are as perfect *in their kind* as the things that went before them. Tried by this test, comparing our general system of steam locomotion with our previous system of horse locomotion, we are impelled to admit that the stewards of steam have done far less with their ten talents than the stewards of animal power did with their one talent, whether commercially or mechanically. . . .

"The first mechanical principle involved is that the 'road' must be of sufficiently homogeneous structure to carry the rails and sleepers, and sustain the load of engines and carriages without crushing. It must, moreover, be sufficiently porous to permit of water entering the surface passing away freely in drains below, or the surface must be so impervious as to prevent water from entering. The latter system has never yet been taken into practical consideration. . . . Railways are fast getting into the condition of highways, as to their finances; and this will go on until such time as they shall be managed as systematically and economically as private business. When this time comes it will be found that an economy of from thirty to fifty per cent. in coke, and mechanism, and repairs, has yet to be attained. How this is to be accomplished on existing lines, with current traffic, is yet a problem. That it cannot be without proportioning the rails and road to the loads running over them, is quite certain. We shall return to the subject again."

Ports Efficiency Committee

A NUMBER of changes are announced in the Ports Efficiency Committee, which was appointed originally by Lord Leathers in March, 1952, and given the task of securing improvements in the flow of cargoes through United Kingdom ports. The committee meets under the chairmanship of Sir Ernest H. Murrant, the chairman of Furness Withy and Co., Ltd., and it is at present investigating the problems involved in delays to road vehicles at the docks. The recent announcement states that Sir Douglas Ritchie has resigned on account of ill-health, and Mr. F. A. Pope has resigned on ceasing to be a full-time member of the British Transport Commission. The following three new members have been appointed to the committee by the Minister of Transport and Civil Aviation: Sir Robert Letch, general manager of the docks division of the British Transport Commission and chairman of its docks board of management; Sir Eric Millbourn, adviser to the Minister on shipping in port; and Mr. Leslie E. Ford, general manager of the Port of London Authority.

Turbine Airliners Enter B.O.A.C.

ON Friday last, Certificates of Airworthiness were issued to two Bristol "Britannia 100" airliners. Subsequently, we were able to fly in one of the machines on the delivery flight from Filton to London Airport, where the aircraft were handed over by Sir Reginald Verdon Smith to Sir Miles Thomas, chairman of British Overseas Airways Corporation. Sir Miles forecast that in the early summer the "Britannia" would be operating between London and Johannesburg, with stops at Cairo and Nairobi. Aircraft of this kind have been flown by B.O.A.C. crews over many of the Commonwealth routes already, and the training of flying staff will now proceed. Spares, tools and equipment have already been delivered. The prototype "Britannia" first flew in August, 1952, and over 2700 hours have been flown by these aircraft. The aircraft delivered were the third and fourth production machines, one having accommodation for ninety tourist passengers and the other for fifty-four first-class passengers. The "100" series aircraft take off at up to 150,000 lb, and can carry their full 25,000 lb payload 3730 miles, or half as much over 5000 miles; "300" machines will have a longer fuselage and carry a greater payload over similar ranges. The "Britannia 310" is a long-range aircraft capable of non-stop, all-weather services across the North Atlantic.

The Royal Navy in 1955

No. I

IN the light of the enormous destructive power of thermo-nuclear weapons there seems less likelihood than ever before that full-scale war will ever again be used as an instrument of any nation's policy. None the less, until human nature changes, the possibility remains that a spark—a minor conflict in some part of the world—might start off hostilities on a major scale. British defence policy must therefore be based on two considerations: our Fighting Services, and those of our allies, must be built up into the most powerful deterrent-offensive force that can be achieved. And our defence measures must ensure that this country has the best possible chance of survival in a war which would be a struggle for survival of the grimmest kind. In achieving these aims, the Royal Navy has a major part to play. The particular attention paid to the build-up of anti-submarine and minesweeping vessels when rearmament started in 1951 left the impression that the Royal Navy was a small-ship Navy destined only for trade protection and other defensive tasks. Publicity for anti-submarine and anti-mine warfare and concentration of new construction on those types of vessels have paid the unforeseen and unwanted dividend of driving the Navy's offensive function out of the public mind. The Defence White Paper, 1955, will, it is hoped, do a great deal to eradicate this impression, in view of its firm emphasis on the Navy's offensive function and special importance in a nuclear war. Pointing out that the main contribution to the deterrent-offensive force is to be made by V-bombers, the White Paper adds: "The Navy also makes its contribution of heavy carriers to the allied striking fleet whose mobility and offensive power will add powerfully to our ability to hit the enemy either independently or in support of allied land forces and land-based air forces." Carriers provide, in fact, a mobile, elusive and hard-hitting offensive force which can be quickly deployed wherever required on or before the outbreak of hostilities. We are also inclined to forget in these days of hydrogen and atom bombs that Britain is still an island. It is now more than ever essential that the Navy should be able to destroy or contain the naval forces of our enemies so as to allow free movement of supplies and troops. The Soviet Government clearly realises this, for it is building a powerful navy, not to gain and maintain control of the sea communications, but to make it very difficult for the combined N.A.T.O. navies to protect their world-wide trade routes. It is estimated that by 1957 the Soviet Navy will have 30 modern cruisers, 150 destroyers, 500 submarines and 4000 naval aircraft, though these figures may well be affected by the announced reduction of 640,000 in the total personnel strength of the Soviet Armed Forces. In his memorandum accompanying the current Navy Estimates the First Lord set out the types of ships required by the Royal Navy to carry out its tasks—carriers operating the latest types of aircraft; powerful ships armed with guided weapons; escort vessels, submarines and amphibious forces, and minesweepers. Whether adequate numbers of these types of vessels are already available or will be available in the next few years is discussed in the paragraphs which follow.

The Strength of the Royal Navy To-day and To-morrow

Battleships.—The First Lord, it will be noted, made no mention of battleships in his list of categories of ships required. Indeed, it is almost dangerous to mention the word in Parliament in view of the general belief that these vessels are obsolete—a belief encouraged to some extent by the Admiralty's decision that it is not worthwhile converting our existing battleships to guided missile firing. Both the Royal Navy and the United States Navy are, however, retaining the ships of this type completed during or since the war. We have five of them in reserve—four are mothballed and maintained at negligible cost—and it would be most unwise to scrap them. For until other types of vessels are available with an armament capable of taking on a "Sverdlov" class cruiser, battleships—if, as one may hope, they are not bombed before being ready for sea—would be of great value as the hard core of a Task Force. Moreover, all our relatively few cruisers may well be employed in the Eastern Atlantic or Indian Ocean, rounding up raiders attacking the trade routes, with none left available as escorts for carrier Task Forces. In any event, the present position is likely to change drastically after the next fifteen to twenty years. Ships may well then fight each other at long range, not with aircraft as they did in the Pacific war, but with guided missiles. Ships armed with ship-to-ship guided missiles would then become the capital ships and—if the views of the experts are to be relied on, and long-range bombers are replaced by the long-range rocket—it may well prove necessary to build ships large enough to carry both the smaller ship-to-ship missile and the larger rocket with a range of from 500 to 1000 miles. Under these conditions, the value of seapower will again become self-evident when faced with an enemy who does not attempt to dispute control of the sea communications.

Cruisers and Guided Missile Ships.—A carrier, when her aircraft, under conditions of mist, gales and heavy seas, cannot operate effectively, if at all, would be hard put to it to defend herself against attack by enemy cruisers. Escorts must therefore be provided, powerful enough to deal with this form of attack. Moreover, even under the most favourable weather conditions, cruisers, or equally powerful vessels, are required in considerable numbers, if possible co-operating with carriers, to protect merchant ships on our worldwide trade routes. The Royal Navy has only twenty-three cruisers, including the "Argonaut" and "Phoebe," which have recently been placed on the disposal list. None is armed with a gun larger than 6in and many of them are war weary and unmodernised. Five have already lived their normal life of twenty years. When, however, comparing them with the thirty Soviet modern, fast, powerful cruisers—many armed with 7·1in guns—it must be borne in mind that Britain is a member of the Commonwealth and N.A.T.O. None the less, it would be unwise to rely on the United States cruisers (which may be fully occupied in the Pacific) for assistance in defending our trade routes in the Indian Ocean and in the North and South Atlantic. The First Lord points out that the Admiralty has been waiting for the green light and is only now able to proceed with the design and construction of vessels to replace our existing cruisers. A beginning is to be made with the laying down of guided missile ships when the trials to be carried out this year of an anti-aircraft guided missile have proved satisfactory. A maintenance vessel—the "Girdleness"—is now being adapted for the purpose.

It is important to note, however, that these new ships are to have guns as their main armament. Even the United States, which started developing guided missiles three or four years ahead of us, does not yet possess a reliable ship-to-ship guided missile. The "Regulus"—a guided flying bomb—has been developed by the United States Navy for firing from surface ships and submarines, but this is not an effective replacement for the shell. In view of its large size and relatively low speed, it would be no more immune from anti-aircraft fire than is a piloted bomber. In brief, ships with a powerful main armament of heavy guns are still an urgent requirement for the Royal Navy and the Admiralty has therefore decided to complete the three "Tiger" class cruisers laid down during the war and to modernise the "Royalist" and the best of our other existing cruisers to help close the gap in the intervening years. The "Tiger" class will each have a main armament of four 6in guns of a new kind with a very high rate of fire. Though they will lack a modern guided missile anti-aircraft armament, they will at least provide us with cruisers capable of taking on the "Sverdlov" class on equal terms. There are also available the eight "Daring" class ships, which might well be classified as small cruisers. Laid down during the war as destroyers, they

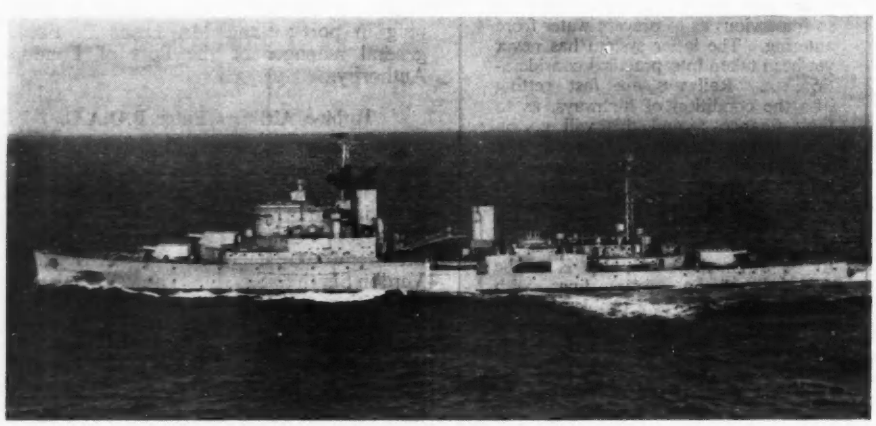


Fig. 1—H.M.S. "Newfoundland," an 8800-ton cruiser with nine 6in guns. Completed 1942; since reconstructed and modernised

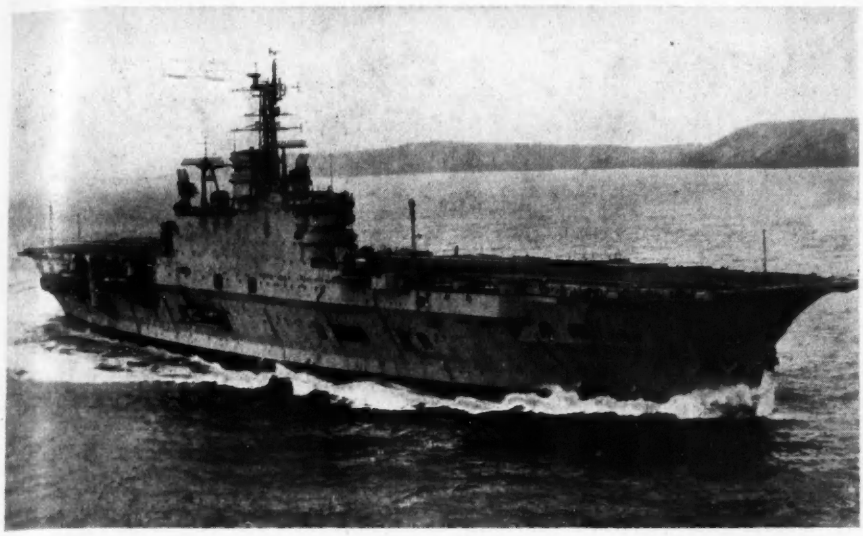


Fig. 2—H.M.S. "Ark Royal," 36,800 tons, speed 31·5 knots. Fitted with angled deck, side lift and two steam catapults

are of 2600 tons, with a powerful torpedo armament for attacking heavy ships and a gun armament of six 4·5in twin turrets. Finally, when not required for minelaying, our three 40-knot minelayers of about the same tonnage as the "Daring" class and with an armament of from four to six 4in guns, might well be used as escort vessels for Task Forces. If, however, it is remembered that we started World War II with fifty cruisers and that the relatively few German cruisers and armed merchant raiders took a long time to round up, our cruiser situation cannot be regarded as satisfactory. One can only hope that, despite our other defence commitments, a substantial replacement programme will be begun this year and that we shall not have to rest content with "one prototype guided missile ship pending developments."

Aircraft Carriers.—It is generally recognised that there are two kinds of carriers—the heavy carrier for fleet work and the escort carrier to provide air cover for merchant ships on the wide oceans. But the reasons for the great variation in the size of heavy carriers are not always understood. Why should the 13,000-ton "Glory" class, completed at the end of the war, be followed some years later by the 36,800-ton "Eagle" and "Ark Royal," and more recently by the 20,000-ton "Hermes" class? And why is the United States building 60,000-ton carriers? At the outbreak of World War II Britain had under construction five carriers of about 26,000 tons and 31 knots speed. Vessels of this performance were required to enable piston engine aircraft to fly off and land-on and to provide an adequate parking ground, though by that time it was becoming the practice to catapult aircraft instead of flying them off. Meanwhile, aircraft were getting larger and faster, but in view of the need for economy in the construction of large ships, Britain, apart from laying down four of the "Eagle" class, limited her wartime carrier construction to sixteen vessels of 13,000 to 14,000 tons, with a speed of 24½ knots—ships which could operate small numbers of piston-engined fighters and anti-submarine aircraft and would not take long to build. Later, in 1944, eight carriers of the "Hermes" class were ordered—vessels of 18,000 to 20,000 tons and of 30 knots speed. With the coming of the very much faster and heavier jet aircraft after the war it looked as if nothing smaller than the "Eagle" would meet requirements, and this started a heated controversy, both in and out of Parliament, on the value of the heavy carrier. "Is she not," the air enthusiasts suggested, "extremely vulnerable, far too expensive and indeed wholly unnecessary in view of the range of shore-based aircraft?"

At that time indeed there seemed no possible solution to the problems of catapulting and landing-on jet aircraft except from a very large carrier. The strength and size of the conventional hydro-pneumatic catapult had had to be constantly increased and there was no margin left for the still heavier aircraft of the future. Fortunately, British inventive genius produced a steam operated catapult capable of launching the heaviest carrier-based aircraft likely to be required, even across wind, and this kind of catapult is now being, or will be, installed in all operational carriers of the Royal Navy and the Dominion and United States navies. Yet another British innovation—the angled flight deck—has largely solved the problem of landing-on. The conventional shape of the flight deck has been modified by extending it to permit aircraft to fly-on at an angle varying from 5½ to 8 deg. to port, relative to the ship's fore and aft line. The forward area of the deck is thus left clear as a parking ground and an aircraft landing-on, if it fails to hook on to one of the arrester wires, can fly-off again and make another attempt. Thus, although carriers still require high speed for landing-on, it is now possible to obtain in vessels of the "Hermes" class the performance required to operate all types of aircraft likely to be used by the Royal Navy. Three of these ships have been completed at a cost of about £10½ million each, compared with £16 million for the "Eagle." Why then are the Americans building carriers of 60,000 tons costing £71 million? The United States Navy is being trained to fight a land power from air-sea bases—to attack inland targets with large, heavy, medium range bombers (thus reinforcing strategical bombing by long-range shore-based aircraft) and to land troops by helicopter and aircraft. It is misreading the Defence White Paper to suggest that British carrier-based aircraft are intended for such duties. Naval strike aircraft—the "Wyvern" and the aircraft which will replace them—have a relatively small range and are intended primarily for attacking hostile cruisers raiding the trade routes and to provide air cover in amphibious operations. But they will also "hit the enemy" by attacking his ports and war potential installations on or near the coast. For this country the defence of the sea communications is vital; strategic bombing, it is felt, should be left to the R.A.F. Moreover, ships of 60,000 tons are sufficiently valuable to offer tempting targets for guided nuclear missiles and it seems preferable from an operational point of view to have three carriers of about 20,000 tons—rather than one three times that size—to provide a given number of aircraft. Thus it seems more logical to discuss the carrier position in two categories—fast carriers, which have been completed or reconstructed in the last two

Fig. 3—H.M.S. "Bulwark," a "Centaur" class carrier, 20,350 tons, speed 30 knots. Fitted with modified angled deck

or three years ; and slow carriers, completed during or immediately after the war.

Fast Carriers.—When the " Hermes," now being completed, and the " Victorious "—the only one of our pre-war designed fast carriers worth while reconstructing and modernising—join the Fleet, the Royal Navy will have seven first-rate carriers, though the " Eagle," " Albion," " Centaur " and " Bulwark " have yet to be fitted with steam catapults. Two " Eagle " class and four " Hermes " class carriers were cancelled at the end of the war. The completion of the " Ark Royal " was deliberately postponed to enable modern improvements to be incorporated, including a 5½ deg. angled deck, steam catapults, a new and much stronger arrester gear, a side lift in addition to central lifts, the mirror deck landing aid, hangers with improved ventilation and an air crew refreshment centre. The " Hermes " class are 70ft shorter than the " Eagle " and operate only about half the number of aircraft, but are equally efficient from an operational point of view. Many more than seven modern carriers, however, are required to carry out the tasks laid down in the Defence White Paper and there should be no further delay in replacing our four pre-war designed vessels — " Implacable," " Indomitable," " Indefatigable " and " Illustrious." One of them—the " Indomitable "—has in fact already been placed on the disposal list.

Slow Carriers.—Of the sixteen 24½-knot, medium-size carriers laid down during the war, the " Vengeance " (recently on loan to the R.A.N.) and five others of the 13,000-ton " Glory " class are still in service. One was sold to The Netherlands, another to France, and two were completed as maintenance carriers. Of the remainder—all " Hercules " class (15,700 tons)—two are still half completed, one (the " Magnificent ") is on loan to the Royal Canadian Navy, and another (the " Sydney ") was sold to the Royal Australian Navy. The " Majestic " (now H.M.A.S. " Melbourne ") has recently been completed for the R.A.N., and the " Powerful " (now H.M.C.S. " Bonaventure ") is being completed for the R.C.N. The two latter vessels have been reconstructed and modernised to take the angled deck, the steam catapult and other modern improvements and will be able to operate earlier jets (" Sea Venoms ") and " Gannets " (turbo-prop anti-submarine aircraft). Landing-on speeds of aircraft may well be somewhat reduced in the future by devices now under investigation, but it is unlikely that the " Glory " class will be reconstructed even to the standard of the " Bonaventure " and " Melbourne." Three of them are now employed giving initial training to General Service and National Service personnel. The future of these carriers must, to a large extent, depend on the Admiralty's plans for trade protection, for they would still be of value for general reconnaissance work and as anti-submarine patrols, operating piston-engine aircraft and helicopters.

Destroyers and Frigates.—Twenty-seven of the Royal Navy's post-war strength of 109 destroyers have now been converted to anti-submarine frigates and eighteen more are, or will be, taken in hand, though some of the latter may be converted for aircraft direction duties. With the sale last year of four to Israel and Egypt—two to each country—we shall thus be left with some sixty destroyers, in addition to the eight ships of the " Daring " class. Destroyers, in addition to their torpedo armament for attacking heavy ships by day and night, have also a powerful gun armament to prevent similar attacks on their own heavy ships. The

Fig. 4—H.M.S. " Highburton," 360 tons ; one of the new coastal minesweepers and the first to be fitted with Napier " Deltic " lightweight diesel engines

Soviet Navy has no modern heavy ships larger than a cruiser, but will soon have about 150 modern destroyers, and it is clear therefore that we must continue building vessels of this type. Indeed, this has been recognised in the current Navy Estimates, which provide for the laying down of " two fleet escort ships that will embody the newest developments in the destroyer field." The First Sea Lord also announced a few months ago that the main operative strength of the Fleet is being built round fast battle groups, each consisting of one carrier, one cruiser and a squadron of destroyers. Moreover, " homing " torpedoes and improvements in the performance of these missiles make torpedo attacks even on a fast cruiser well worth while. On the other hand, fast frigates for the protection of merchant ships against submarines and aircraft are a more urgent requirement at the present time and it is a sound policy to produce these vessels quickly by the conversion of destroyers. There are also twenty-six new frigates under construction—six are almost completed—and eight more are to be built under the current Navy Estimates. Those now under construction are of specialised types—eighteen vessels primarily for anti-submarine duty (six faster and more heavily armed than the remaining twelve), four for the protection of merchant ships against aircraft, and four for aircraft direction duties. The eight additional ships now provided for are, however, to be built as general-purpose frigates, capable of carrying out all these functions. The armaments of frigates vary considerably. Most of the converted destroyers have, besides their powerful anti-submarine armament, two 4in guns, and the six faster and more heavily armed new A/S frigates have two 4·5in guns. The anti-aircraft frigates have a powerful gun armament of four 4·5in guns in two twin turrets and may well be used as fleet escort vessels. The speeds of the newly constructed A/S frigates have not been officially announced, but the twelve slower vessels have only one shaft. All eighteen vessels are equipped with a novel design of geared steam turbines of high power, while the two other types have Admiralty standard Range I diesel engines. Mention must also be made of our wartime frigates. Twenty have recently been placed on the disposal list, leaving about 130 still available for service. Many of them have been modernised since the war. They are too slow to hunt and destroy the modern submarine, but with their asdic installation should prove most useful as patrol vessels as a counter to submarines firing nuclear guided missiles at shore targets. Finally, the Royal Navy has seven surveying ships, one new and six converted from frigates.

Minesweepers and other Small Craft.—Magnetic and influence mines have made it impossible to rely on adapting trawlers and drifters for minesweeping in an emergency.

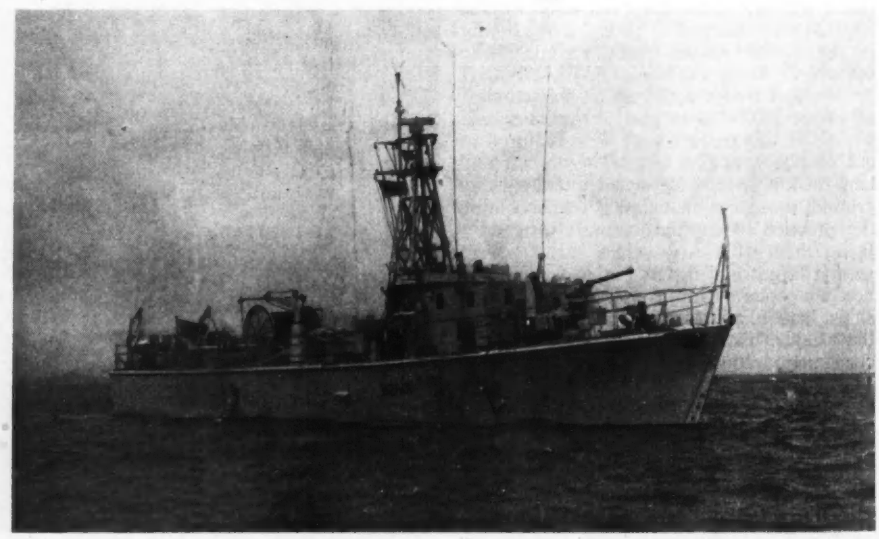
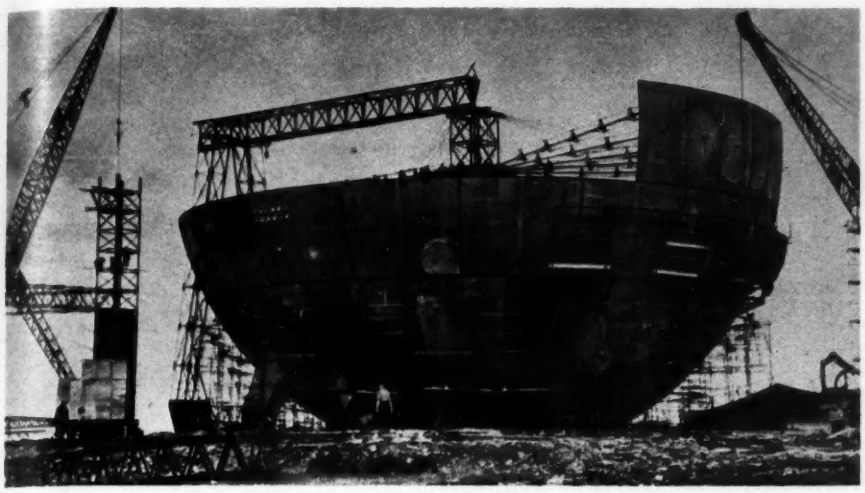


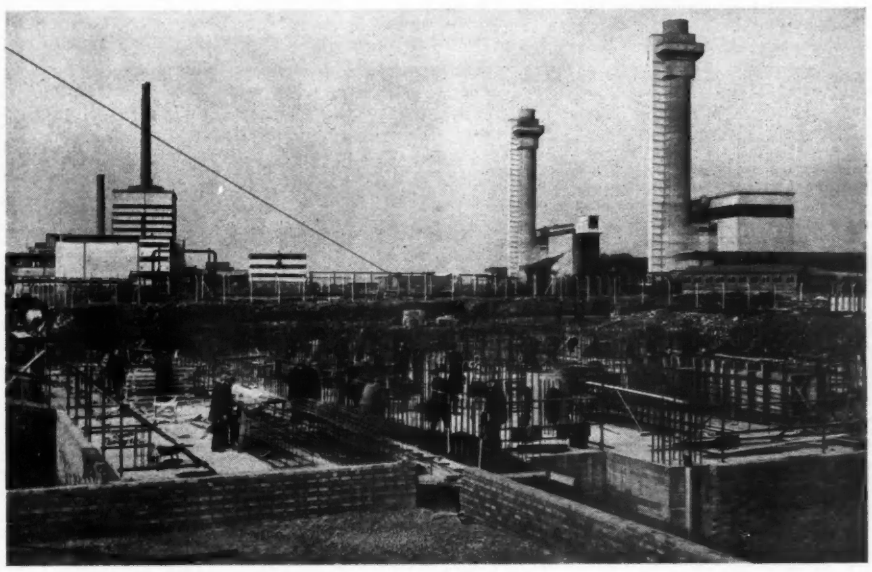
Fig. 5—H.M.S. " Inglesham," 100 tons ; one of the new inshore minesweepers for shallow water operations

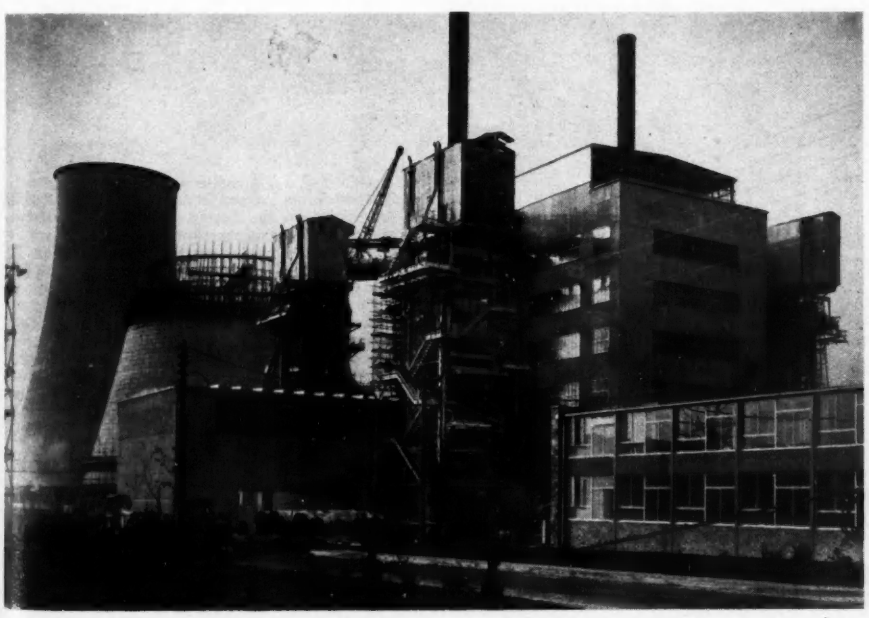
BRITISH ATOMIC POWER PROJECTS



Long term developments in the U.K. atomic energy programme are envisaged in the establishment under construction at Dounreay in the North of Scotland where several reactors of experimental or advanced design will be built, alongside plants for fabricating fuel elements and treating them after irradiation in piles. The first of these projects, the building of a fast "breeder" reactor, was started in March, 1955. It will make use of highly enriched fuel, either uranium 235 or plutonium. There is no moderator, the core is comparatively small and it is enclosed in a steel sphere to prevent the escape of fission products that might be produced as a result of a rapid rise in temperature of the core. This sphere is about 140ft in diameter and is being fabricated on site from steel plate. The state of progress a few months ago is indicated in our first illustration

In the meantime a provisional programme for the development of nuclear power in Great Britain was announced by the Government in a White Paper (Cmd 9389) in February, 1945. This programme involves the construction of twelve nuclear power stations in the next ten years. Work on two of these power stations is to be started in 1957 and they are due to be completed in 1960-61. Two more stations are to be begun about 18 months later. The building of another four stations might start in 1960 and might be followed, after 18 months, by a further group of four. Some of the last group of four might use more advanced (liquid-cooled) reactors. But the earlier stations will use improved versions of the graphite-moderated gas-cooled Calder Hall reactors. Calder Hall will, in fact, serve as a prototype for the first phase of Britain's nuclear power programme. This station is being built in two stages, Calder Hall "B," which is the later station, being essentially a duplicate of the original, Calder Hall "A." Our second illustration shows the site of Calder Hall "B" as it appeared on November 17th last

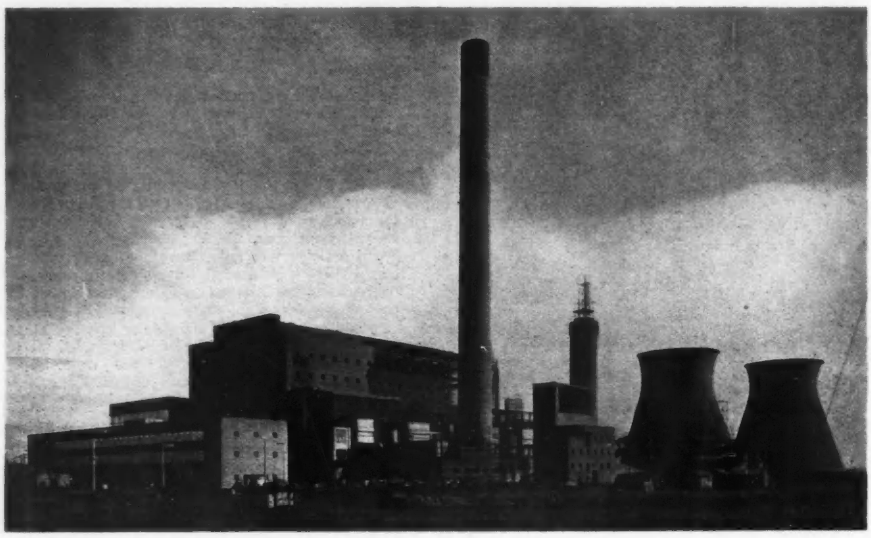




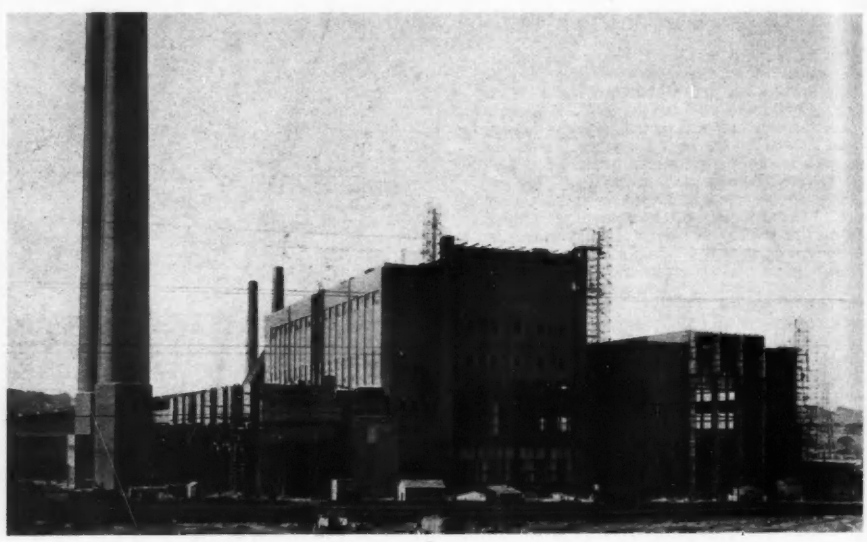
Progress in the construction of Calder Hall "A" power station on the same date can be seen from the third illustration. The station consists of two graphite-moderated gas-cooled reactors, each of which produces plutonium and generates steam in four Babcock and Wilcox heat exchangers. Four 23MW Parsons turbo-alternators are being installed in the turbine hall between the two reactors and will take steam from the eight heat exchangers. Each of the heat exchangers contains separate h.p. and l.p. evaporator, economiser and superheater sections, with separate steam drums and feed pumps. The reactor consists essentially of a graphite lattice with uranium fuel elements and control rods, forming a structure weighing 1000 tons contained in a cylindrical pressure vessel made by Whessoe, Ltd. Carbon dioxide coolant is circulated through the reactor and heat exchangers by four single-stage centrifugal blowers, each driven by a 2000 h.p. d.c. motor with Ward-Leonard control to give a 10 : 1 speed range. A separate "dump" condenser is being installed so that the full load steam output of the two reactors and heat exchangers can, if required, by-pass the turbines. No. 1 reactor to the right of the cooling towers is about six months in advance of No. 2 reactor and is due to be generating power this year

POWER STATIONS OF 1955

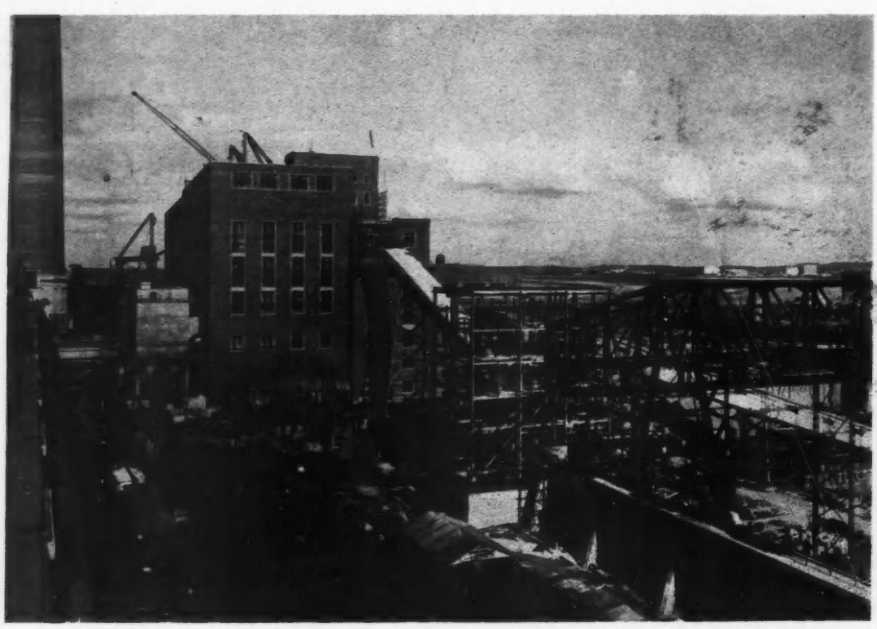
(EXTERNAL VIEWS)



By mid-December the Central Electricity Authority had commissioned twenty-eight new generating sets with a total installed capacity of 1277·5MW, and forty-five boilers with a total steam raising capacity of 15,955 klb per hour. Some of this plant was installed in seven new power stations and the rest in twenty-three existing stations. Three of the new stations are illustrated here. Goldington power station, near Bedford, is in the Eastern Division of the C.E.A. and will have an ultimate capacity of 180MW, made up of six 30MW turbo-alternators. The level of the site, which had been subject to flooding by the Great Ouse, was raised and the structural load-bearing areas were provided with reinforced concrete piles

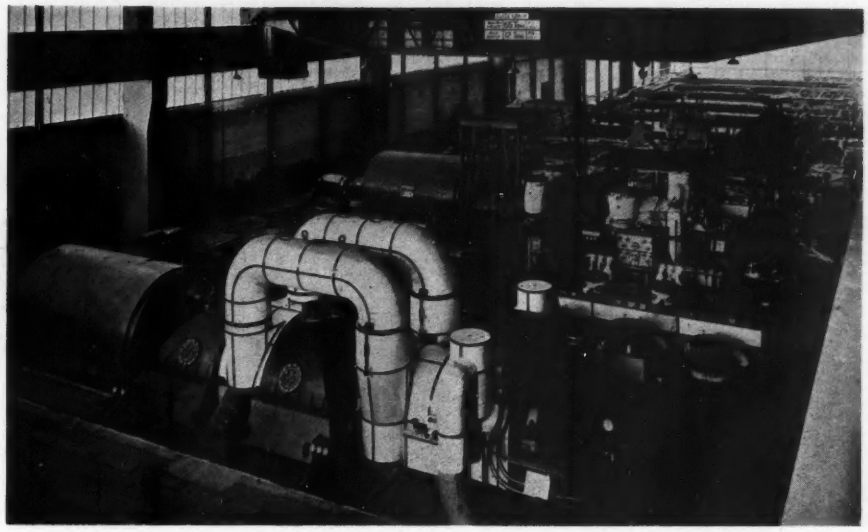


Plant was commissioned during the year in two new power stations, Stella North and Stella South, which are being built near Newcastle upon Tyne by the North Eastern division of the C.E.A. Stella North, which is illustrated here, will, when complete, have an installed capacity of 240MW, consisting of four 60MW turbo-alternators, which will be supplied with steam by four 550 klb per hour boilers fired with pulverised fuel. Coal is supplied by rail from local collieries and the daily consumption in winter will eventually reach about 2300 tons. Ash and dust disposal is effected by dumping into the sea, the annual quantity being about 120,000 tons

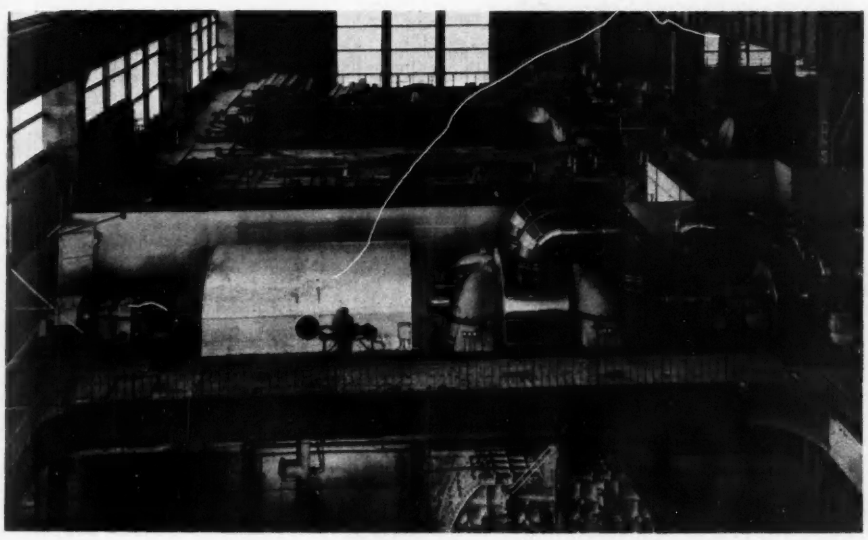


Portishead "B" power station, illustrated here, is being built on the Severn Estuary near Bristol, in the South-Western Division of the Central Electricity Authority. When the installation is complete twelve 300 klb per hour boilers will supply steam to six 60MW turbo-alternators. Coal supplies are sea-borne from South Wales. Circulating water is drawn from the River Severn through four concrete-lined tunnels of horseshoe section, equivalent to a circle of 9ft diameter. These culverts discharge into 45ft diameter pump pits, each of which is associated with two turbo-alternators

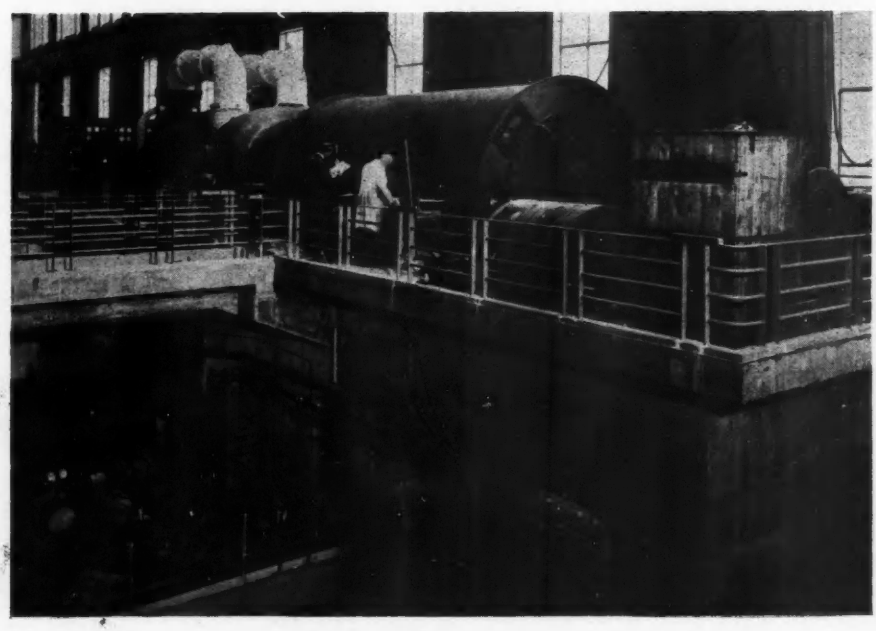
POWER STATIONS OF 1955
(INTERNAL VIEWS)



Two of the six B.T.H. 30MW turbo-alternators and the Clarke Chapman unit boilers were installed during the year at Goldington. The boilers are 300 klb per hour units which deliver steam at the stop valve at 600 lb per square inch and 850 deg. Fah. Circulating water for the condensers is taken from the River Ouse by a 720ft long inlet channel to a pump house accommodating six 22,000 gallons per minute pumps. Five r.c. cooling towers, each capable of handling 1,200,000 gallons per hour, will supplement the river circulating water supply. The consultants are Merz and McLellan and Sir Alexander Gibb and Partners. Main civil engineering contractors : Mitchell Construction Company, Ltd.; Bierrum and Partners, Ltd., and Film Cooling Towers (1925), Ltd.

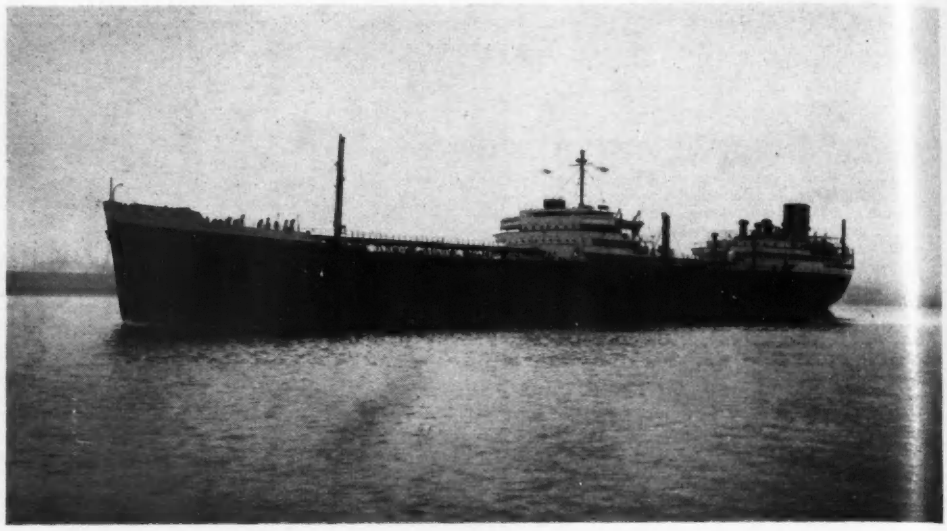


Two of the Parsons 60MW turbo-alternators and the associated Clarke Chapman boilers were installed at Stella North, the turbine hall of which is illustrated here. The turbines are three-cylinder machines (with double-flow l.p. cylinders), which take steam at 900 lb per square inch and 900 deg. Fah., and are coupled to hydrogen-cooled alternators generating at 11·8kV at 3000 r.p.m. The output is stepped up by generator transformers to 132kV. Messrs. Merz and McLellan are the consulting engineers and the main civil engineering contractors are Sir R. McAlpine and Sons, Davenport Engineering Company, Ltd., D. Theaker and Co., Ltd., Cleveland Bridge and Engineering Company, Ltd.

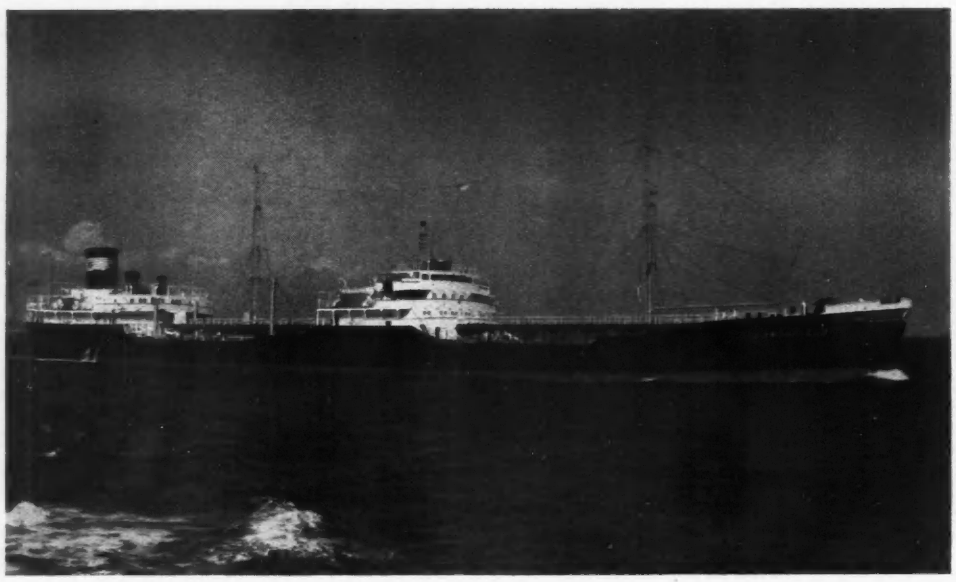


The main items of plant installed and commissioned in Portishead "B" power station during the year were a Metropolitan-Vickers 60MW hydrogen-cooled turbo-alternator and the two 300 klb per hour pulverised-fuel-fired boilers built by the Mitchell Engineering Company, Ltd. The steam conditions are 900 lb per square inch and 900 deg. Fah. at the stop valve. The accompanying illustration shows the first turbo-alternator undergoing drying-out of the stator windings. The consultants are Sir William Halcrow and Partners, and the main civil engineering contractors are C. Brand and Son, Ltd., Sir William Arrol and Co., Ltd., and J. Laing and Son, Ltd.

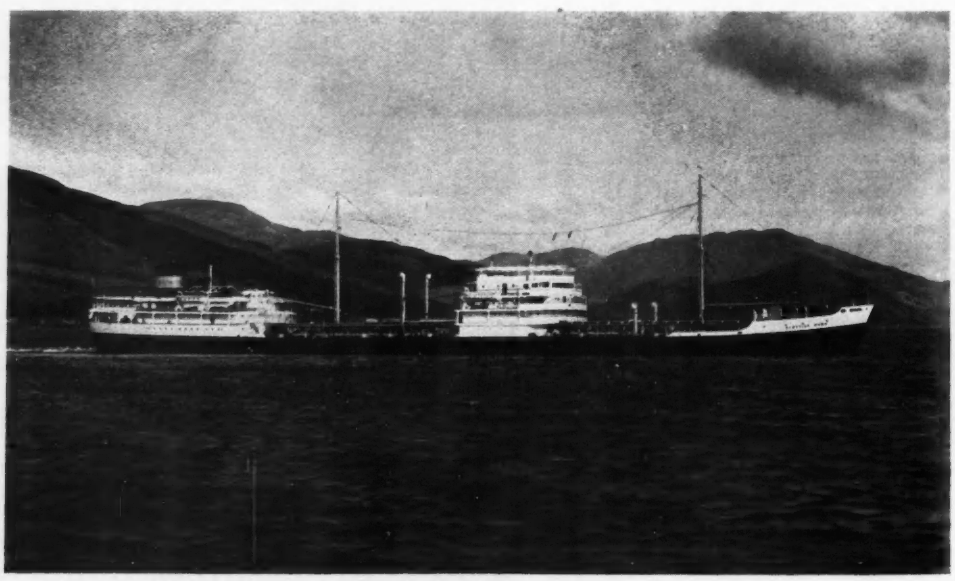
OIL TANKERS OF 1955



S.T.S. "Vexilla." The first of six 31,000 tons deadweight oil tankers ordered by Shell Tankers, Ltd., was delivered by Cammell Laird and Co. (Shipbuilders and Engineers), Ltd. The ship has the following particulars: length between perpendiculars 635ft, breadth moulded 84ft 3in, depth moulded 46ft 3in, draught 34ft, service speed 16½ knots, ten sets of cargo compartments and one main cargo pump room. Four 1600 tons per hour turbine-driven pumps handle the cargo oil and ballast and one 550kW mixed pressure and one 550kW constant pressure turbo-alternators and a 150kW diesel-driven alternator provide the electrical power. Propulsion is by a set of double-reduction geared turbines of 13,000 s.h.p. at 105 propeller revolutions per minute, taking steam at a pressure of 600 lb per square inch gauge and a temperature of 850 deg. Fah., from two Babcock and Wilcox boilers

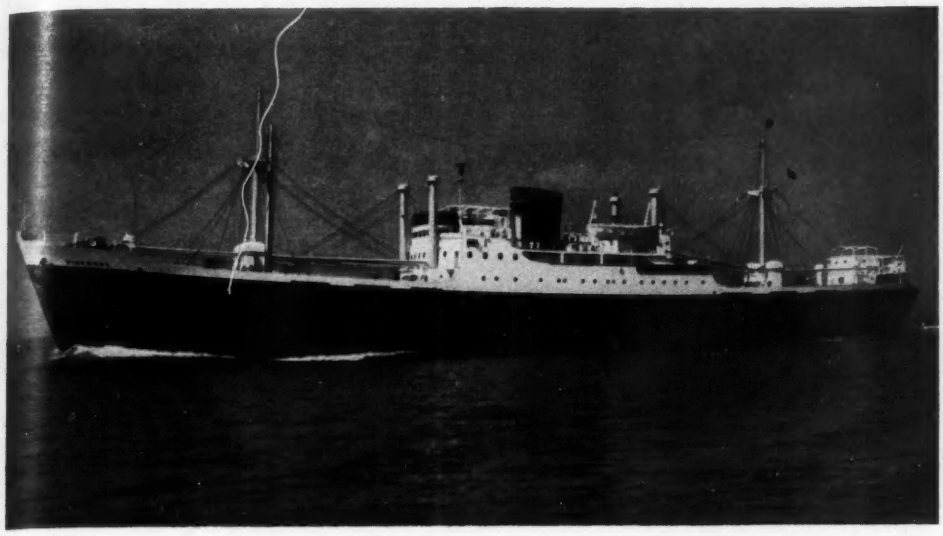


S.T.S. "Forthfield." Built by Hawthorn Leslie (Shipbuilders), Ltd., for Hunting and Son, Ltd., has a length overall of 555ft 9in, a breadth moulded of 69ft 3in, and a depth moulded of 39ft. The ship carries a deadweight of 18,000 tons. There are thirty-three cargo oil compartments and one main cargo pump room equipped with four vertical centrifugal turbine-driven pumps connected to a 10in diameter piping system. Electric power is supplied by two 550kW turbine-driven alternators and one 200kW diesel-driven alternator. The propelling machinery, constructed by Hawthorn Leslie (Engineers), Ltd., consists of a set of double-reduction geared compound turbines developing a maximum power of 8250 s.h.p. when supplied with steam at a pressure of 500 lb per square inch and a temperature of 800 deg. Fah. by two Foster Wheeler water-tube boilers

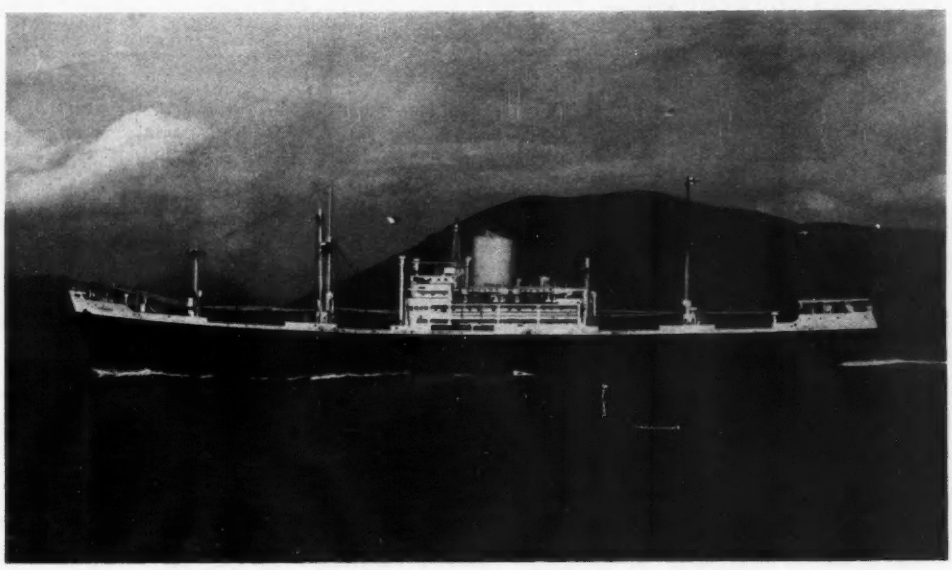


M.T. "Scottish Hawk." The Scottish Tanker Company, Ltd., took delivery of this 16,400 tons deadweight tanker from the Greenock Dockyard Company, Ltd. The ship has a length between perpendiculars of 512ft, a breadth moulded of 69ft, a depth moulded of 38ft 6in, a mean draught of 29ft 10in, and a service speed of 14 knots. There are nine centre and eighteen wing cargo oil tanks and two cargo pump rooms, each equipped with two 500 tons-per-hour cargo oil pumps and one 80 tons-per-hour stripping pump. Electric power for the various ship services is provided by one 75kW steam-driven generator and two 150kW diesel-driven generators. The propelling machinery consists of a Wallsend-Doxford opposed piston oil engine having six cylinders of 670mm diameter by 2320mm combined stroke and developing 6400 b.h.p. in service. Steam for auxiliaries is supplied by two cylindrical boilers arranged for exhaust gas firing

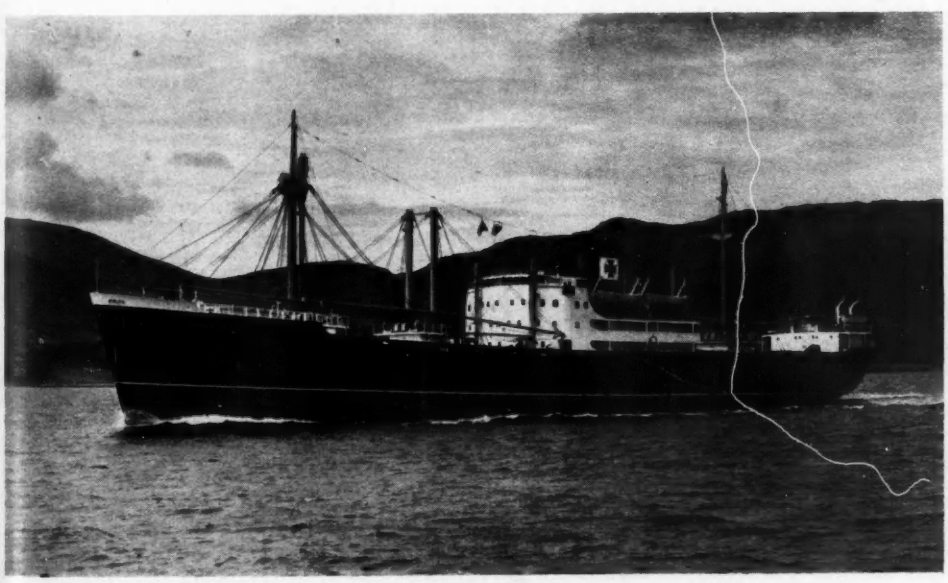
CARGO-PASSENGER SHIPS OF 1955



The M.V. "Pinemoor," which has accommodation for twelve passengers in single-berth state rooms and is designed for the carriage of citrus fruits and general cargo, was completed by the Burntisland Shipbuilding Company, Ltd., for Johnston Warren Lines, Ltd. A deadweight of 4900 tons is carried on a loaded draught of 21ft 9¾in and the following dimensions: length between perpendiculars 345ft; breadth 52ft 7in and depth moulded to shelter deck 32ft 4in. The deck machinery is steam-driven and a 25-ton derrick, two 10-ton and ten 5-ton derricks serve the four large cargo holds. An oil-fired horizontal multi-tubular boiler and a vertical exhaust gas boiler supply the steam for the auxiliaries and the propulsion machinery consists of a 3300 b.h.p. Hawthorn-Doxford opposed piston oil engine having four cylinders of 600mm diameter by 2320mm combined stroke

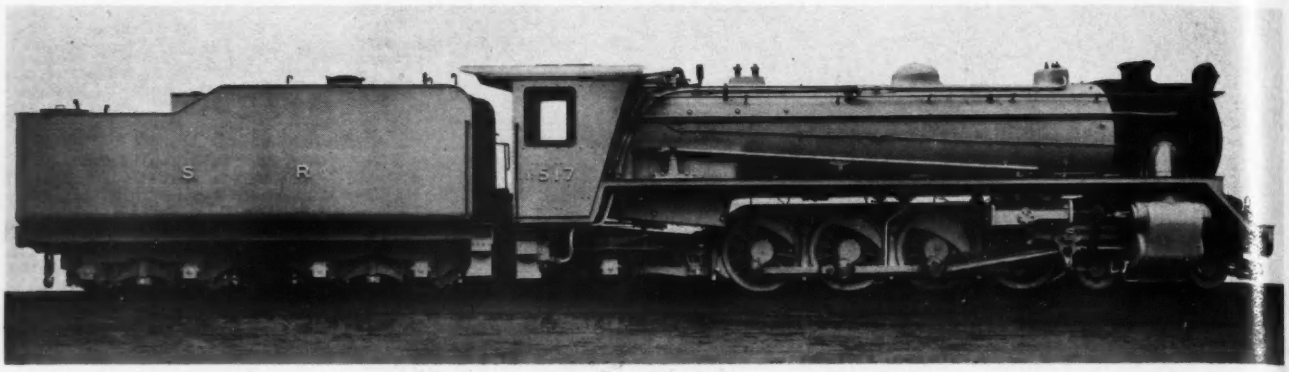


The S.S. "Pizarro," built by the Greenock Dockyard Company, Ltd., for the Pacific Steam Navigation Company, has a length between perpendiculars of 476ft, a breadth moulded of 66ft, a depth moulded to the upper deck of 40ft 8in, and carries a deadweight of 11,100 tons on a mean draught of 28ft. Accommodation is provided for twelve passengers and there are five holds served by one 70-ton, four 10-ton and ten 5-ton derricks operated by electric winches. Three 260kW diesel-driven generators supply the electric power and the ship is propelled by a set of Parsons double reduction geared, triple expansion turbines. The machinery, which develops a service shaft horse-power of 9400 at 108 propeller revolutions per minute, and is capable of developing a maximum of 10,340 s.h.p., is supplied with steam at 415 lb per square inch and a temperature of 750 deg. Fah. by two Babcock and Wilcox boilers

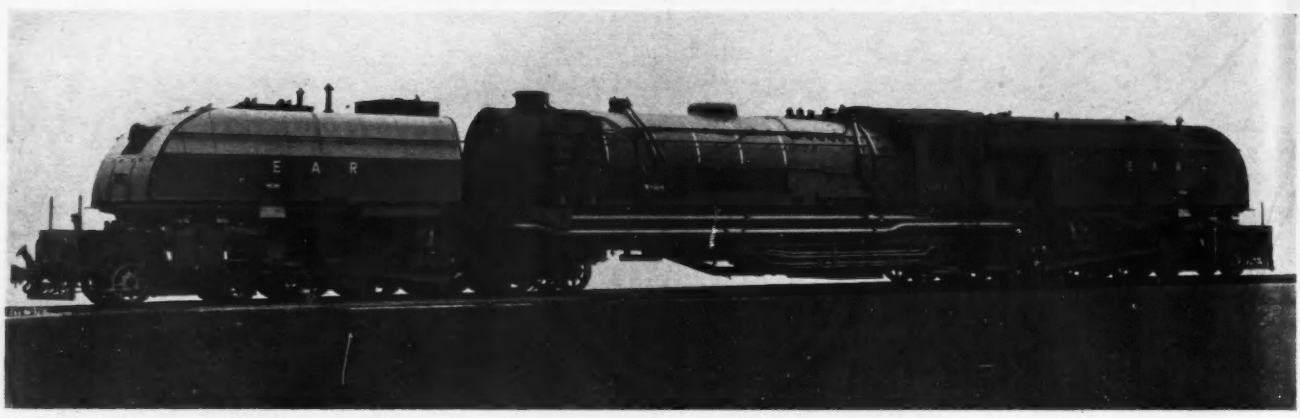


Alexander Stephen and Sons, Ltd., completed the M.V. "Fernvalley" for Fearnley and Eger, of Oslo, and the ship, which is of open shelter deck design, has the following particulars: length 400ft, breadth 57ft, depth 35ft, load draught 23ft, deadweight 6530 tons, and a gross tonnage of 4550. The ship carries twelve passengers in single and double-berth cabins and these, together with the rest of the accommodation, are air conditioned. There are five holds for cargo served by a derrick complement of 5-ton and 10-ton units and one 30-ton heavy derrick operated by sixteen 5-ton electric winches. Electric power is provided by three 180kW diesel-driven generators and the ship is propelled by a Stephen-Doxford opposed-piston, two-cycle, airless injection oil engine having four cylinders of 670mm diameter by 2320mm combined stroke and fitted with a Bibby detuner. Steam is provided by two boilers, one of which can utilise exhaust gas from the main engine

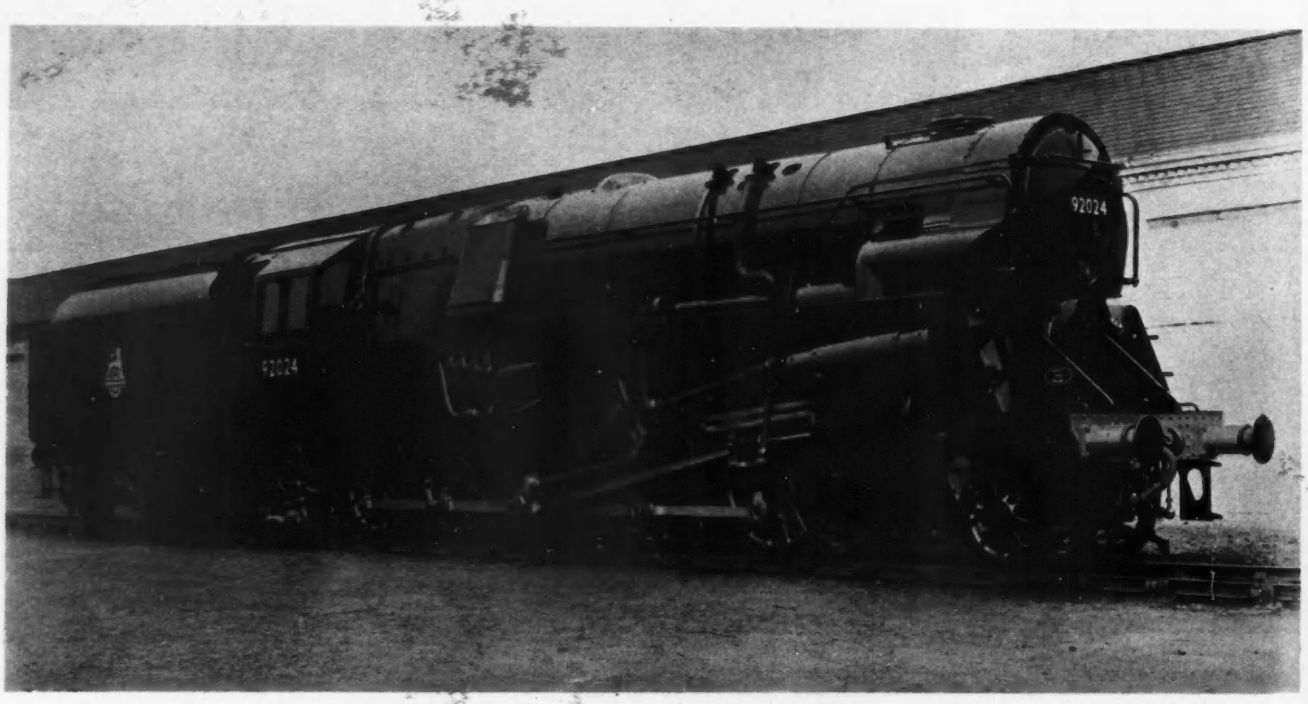
BRITISH-BUILT STEAM LOCOMOTIVES OF 1955



The illustration above shows one of forty-two oil-burning 4-8-2 locomotives being built by the North British Locomotive Company, Ltd., for the Sudan Railways, 3ft 6in gauge. At 85 per cent boiler pressure they have a tractive effort of 35,940 lb

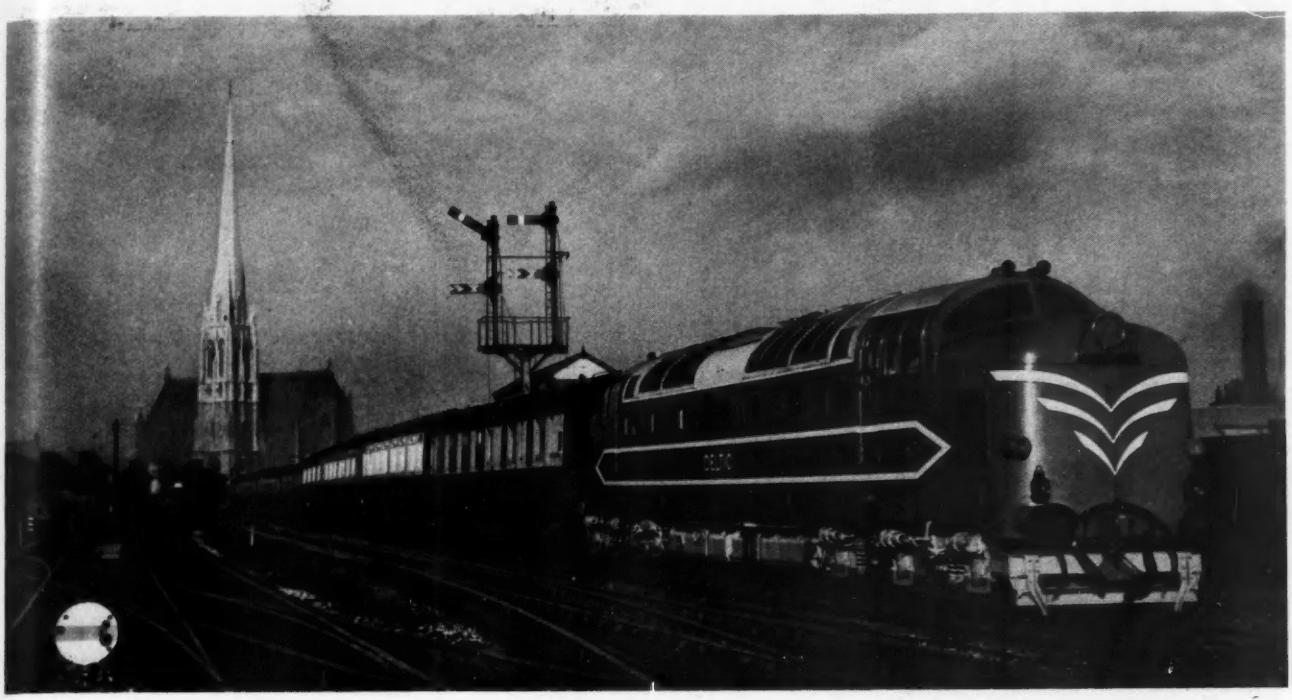


The 4-8-2+2-8-4 Beyer-Garratt locomotive above is one of thirty-four under construction for East African Railways. These locomotives, with their tractive effort of 83,350 lb at 85 per cent boiler pressure, are the most powerful metre-gauge engines in the world



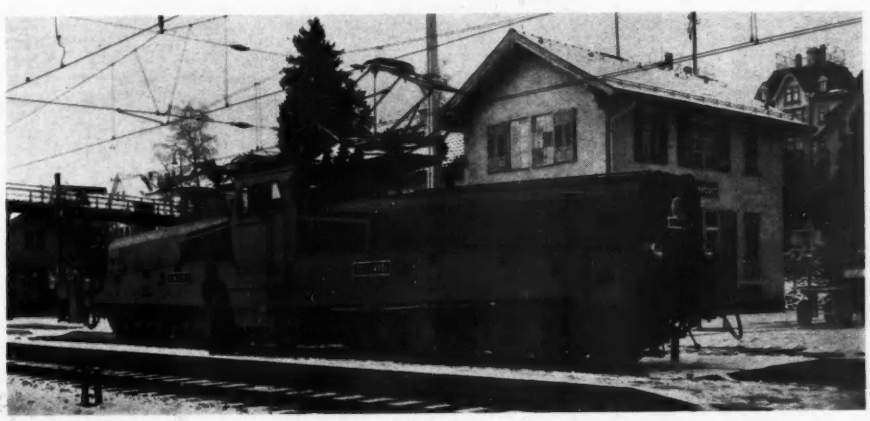
Ten standard class "9" heavy-duty freight locomotives have been built by British Railways with Franco-Crosti boilers. In these locomotives the boiler feed water is preheated in a secondary drum by the exhaust gases

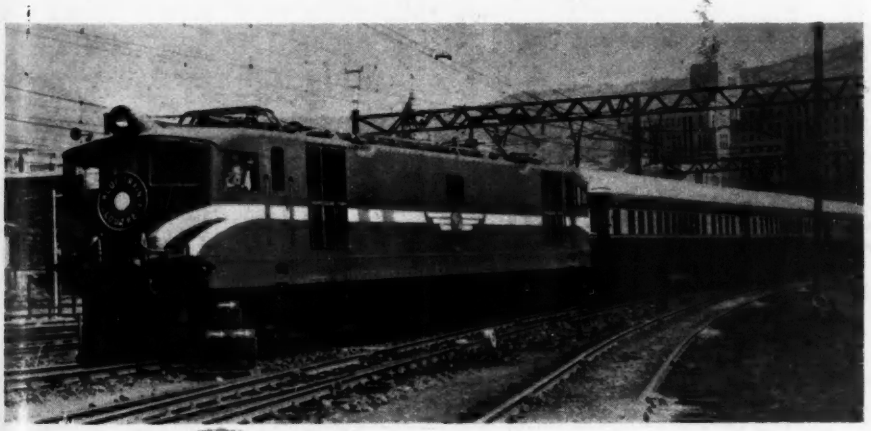
DIESEL-ELECTRIC & ELECTRIC LOCOMOTIVES OF 1955



The English Electric "Deltic" diesel-electric C_0-C_0 locomotive, illustrated above hauling a train, is now undergoing trials in service on British Railways. This locomotive is powered by two Napier "Deltic" engines, each rated at about 1700 h.p. and coupled to a generator rated at 1080kW, 675V at 1500 r.p.m. It weighs about 106 tons in running order, giving an axle loading of 18 tons and a power-to-weight ratio of 72 lb per horsepower. With a maximum tractive effort of 60,000 lb the locomotive has a designed continuous tractive effort of 31,000 lb at 33 miles an hour, and it has a maximum service speed of 90 miles an hour. All six traction motors can, if required, be supplied by either generator set, and with one set in operation the locomotive can maintain its tractive effort by operating at approximately half speed

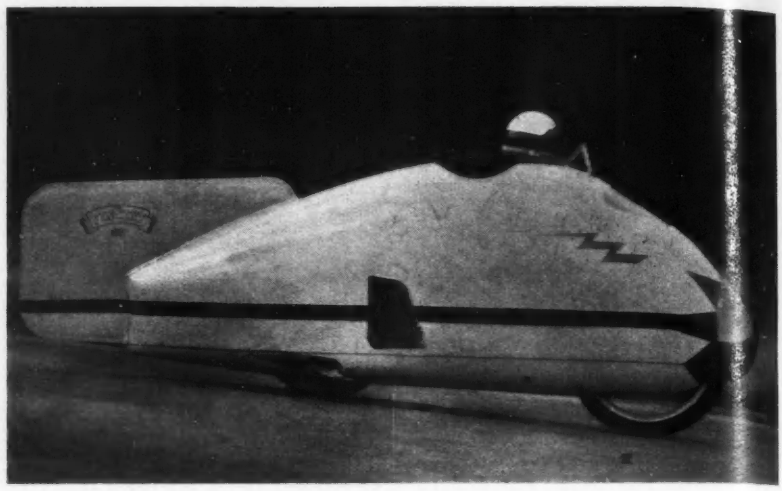
Rapid progress was made in 1955 with the 50 c/s single-phase electrification between Lille, Thionville and Bâle on French Railways. Electrical working on the Charleville-Thionville section was inaugurated on June 29th, thus completing the first stage of the electrification programme outlined in our issue of January 14, 1955, page 61. Locomotives of four types are now operating on this system and the one illustrated here came into service during the year. It is a C_0-C_0 Oerlikon locomotive, with each of its six axles driven by a three-phase squirrel cage motor, the supply being provided at variable voltage and frequency by single-phase/three-phase rotary converters



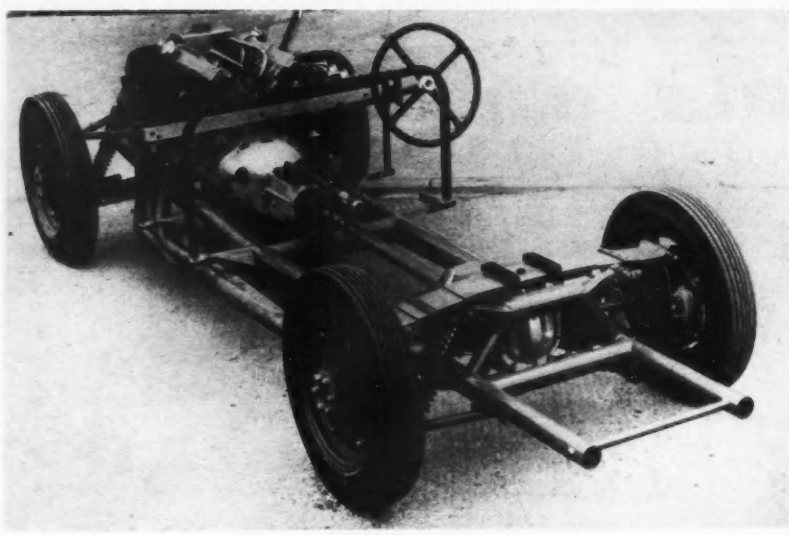


A recent example of railway electrification in the Union of South Africa is shown in our third illustration. The first full year of electric traction on the whole system between Cape Town and Touws River on the South African Railways was completed in 1955 after the suburban section from Bellville into Cape Town had been converted from 1500V to 3000V d.c. at the end of 1954. Passenger and freight services are now worked by North British-G.E.C. 4E-class locomotives of 3030 h.p. Our illustration shows one of these locomotives leaving Cape Town with the Blue Train, bound for Johannesburg

AUTOMOBILE ENGINEERING IN 1955



In July last year the 998 c.c. Vincent "Black Lightning," illustrated, took both the solo and sidecar world's speed records at 185·15 m.p.h. and 163·06 m.p.h. The records were established over a kilometre on a road near Christchurch, New Zealand, the machine being ridden as a solo by Russell Wright and as a combination by Robert Burns, whose 155 m.p.h. on the same machine was the previous three-wheeler record. Apart from the aerodynamic shell, the machine differed from standard only in the cylinder heads and carburettors. Until now, the solo record has been held by supercharged motor-cycles ever since another big vee-twin, a 995 c.c. Brough Superior, took both records in 1937 at 169 and 137 m.p.h. Since these world records were established, a United States record of over 193 m.p.h. has been achieved on the Bonneville Salt Flats by a 649 c.c. Triumph "Thunderbird," modified and fitted into a glass-fibre shell 16ft long



Characteristic of the modern motor vehicle are a structure of great stiffness and a suspension that locates each wheel independently and accurately. Hallmark of the high performance car is a twin overhead camshaft engine with free flow exhaust system and separate tuned induction tracts for each cylinder. Distinctive to the 1500 c.c. H.R.G. are disc, or rather ring, brakes on cast magnesium wheels with detachable rims, and wide-leaf springs with a minimum of internal friction. The coil springs surrounding the rear suspension dampers are rapidly replaceable to permit the handling of the car to be attuned to the roads and loads anticipated. The H.R.G. is not a racing car; the body has doors, and seats two, and there is no provision for hand cranking the engine. The fact that this, an advanced design but nevertheless the prototype of a production car, does bear a resemblance to machines for racing in classes limited by cylinder capacity, demonstrates the harsh refining effect of competition. It is largely to the credit of motor racing that the cheap, convenient, inexact constructions bequeathed by the heavy cars of early days have now become anachronisms. One of the attractive aspects of this field of engineering is that high performance and efficiency so frequently unite instead of conflicting in their demands: the efficient exhaust system and the reduced weight of the rotating masses, for instance, are unalloyed benefits to the car illustrated

The conventional pneumatic tyre developed from attempts to obtain a more comfortable ride on hard surfaces. When they are adapted to drive on soft surfaces their proportions become inconvenient, since to obtain a generous contact area and low ground pressure an immense diameter is needed, resulting in an excessively heavy wheel, and the tractive effort is translated into a torque that needs great gear ratios. A fundamental attack on this problem is made by the Straussler "Lypsoid" tyre, which, as it sinks into soft ground, presents a progressively greater contact area. The use of a cross-section in the shape of a shallow arc allows a much smaller rolling radius for a given area, but offers more room for the brakes within the rim. When the tyre mounts an obstacle the carcase bends inwards under the increased local pressure, since the inflation pressures used are but a few pounds per square inch. The natural frequency of the tyre is around 100 per minute, and it can to a large extent replace the normal suspension mechanism of a vehicle: the tractor which we illustrate was built to demonstrate these tyres and has the axles attached to the frame. On a more conventional vehicle wheels with the arcuate tyres can be steered comparatively easily: on soft ground the wheel does not dig a channel, while on hard surfaces deflection of the tread bars reduces scrubbing between tyre and road

Over £100 million is therefore being spent under the rearmament programme in building 250 minesweepers of two new types—one, a coastal minesweeper for operating in coastal waters and the other, an inshore minesweeper for mine clearance in river mouths and harbour estuaries. Eighty-one of the former and seventy-six of the latter had been completed by the beginning of this financial year; fifty-eight coastal and thirty-six inshore vessels were being under construction or completed and another ten coastal minesweepers are provided for in the current Navy Estimates, making a total of 149 ships of the coastal type. They are 152ft in length with non-magnetic hull and framing, and almost all have standard diesel engines built by, or under licence from, Mirrlees, Bickerton and Day, Ltd. The 112 inshore minesweepers built and building are some 50ft shorter with diesel engines manufactured by, or under licence from, Davey, Paxman and Co., Ltd. There are also sixty-three wartime ocean-going minesweepers available for sweeping ahead of the fleet, but fifty of these ships and over 100 of the new, smaller types are normally maintained in reserve. The valuable work of our coastal forces during the war has not been lost sight of. Forty-six fast patrol vessels have been completed under the rearmament programme and six more are being completed.

These ships are of three types—" Bold," " Dark " and " Gay " classes (the " Bold " class are powered by experimental gas turbines, the " Dark " class by Napier " Deltic," and the " Gay " class by Packard engines). All are designed to be interchangeable as gunboats or torpedo boats. Twenty-six seaward defence vessels have also been built and four more are being completed. These vessels are armed with a small gun and depth charges and powered by the same type of engines as the inshore minesweeper. They are intended for the detection of submarines in the approaches to defended ports. Finally, for amphibious operations the Navy has available one landing ship headquarters, thirty-one tank landing ships and thirty-four tank landing craft.

(*To be continued*)

Atomic Energy in 1955

THE most striking feature of the past year has been the increasing realisation of the importance to the world of the peaceful uses of atomic energy, with a somewhat lessened anxiety as to the probability of its use in warfare. The future may now be said to be regarded with hope rather than fear ; indeed the president of the International Conference on the peaceful uses of atomic energy which met in Geneva in August felt able to say that " For the full industrialisation of the under-developed countries, for the continuance of our civilisation and its further development, atomic energy is not merely an aid—it is an absolute necessity." And it has been wisely said that for such industrial countries as Britain a forecast of future energy requirements shows nuclear power arriving just in time. If the increase planned in the number and capacity of nuclear reactor stations to be built in Britain within the next ten years is pursued with equal energy during the following decade, it can be anticipated that by 1975 there should be a saving of some 40,000,000 tons in the coal needed per annum. Coal grows more and more costly ; its winning becomes steadily more difficult ; and mining itself seems to grow less and less attractive as an occupation. Moreover, in other countries equally endowed with coal to mine there is equal doubt as to the adequacy of the reserves available for any considerable time. The one other fossil fuel, oil, may present much less difficulty in extraction, but it seems at least equally unlikely that probable reserves can meet the increasing demands of coming years. It has indeed been estimated that during this century and its immediate predecessors (say, 500 years in all), the world as a whole may be found to have consumed nearly all the fossil fuels stored in the earth during some millions of years of sunlight.

The fission of uranium is the immediate hope for the alleviation of this problem : and looking further ahead it is conceivable that ingenious research may suggest some way in which the fusion of hydrogen, or other light and plentiful element, will be able to provide an even more abundant supply of power, perhaps calling into use the abundant heavy hydrogen obtainable from the waters of the earth's oceans. Moreover, a possible short cut by which nuclear energy is converted directly into electric energy without the use of steam plant must not be forgotten.

In the meantime our immediate concern is the design of nuclear reactors and this task, as lately pointed out in this journal, it is hard to assign to any single branch of engineering, whether civil, mechanical, electrical or chemical. Its principles borrow something from each of these techniques. Scientists may tend to group nuclear reactors according to their use of slow, medium or fast neutrons ; or of the fuels they use ; or by the nature of the moderator, coolant, reflector, or shield they employ. But the engineer must include all this and add thereto the choice of structural materials, the best disposition of parts, and the safety of the personnel employed. Hence, the field to be surveyed is wide indeed. According to Press statements there are already over 180 United Kingdom firms engaged to some degree in the nuclear industry, whether in manufacturing materials or designing equipment. This number includes four groups of firms who are intimately concerned with the manufacture of complete nuclear power systems.

The prospect was recently assessed by Sir John Cockcroft, director of the British atomic research centre at Harwell, as follows : " The next five years is going to witness the construction in the world of at least ten large-scale nuclear power stations in at least five different types. In Britain we are likely to complete the construction of four large-scale power stations in this period and twelve in the succeeding five years." Looking still further ahead, he was bold enough to foretell a time when the controlled release of energy from the lighter elements of the periodic table would afford an almost inexhaustible supply of energy for all purposes.

The International Exhibitions at Geneva

The two recent international exhibitions at Geneva were devoted entirely to the peaceful uses of atomic energy, and many of the countries attending the Geneva conference were represented. One of the exhibitions was mainly scientific in character, whilst the other made its chief appeal to the general public. Models of a number of reactors were included, not a few from Harwell. The British contribution demonstrated the progress made by the U.K. Atomic Energy Authority and by our industrial firms in the development of nuclear power, in the application of radioactive isotopes to industry, as well as to medicine and agriculture.

The share taken by Britain in this new activity is one of which the country may well be proud, and an increasing export trade may be expected to result. At the same time, it is natural that the number and variety of the reactors that have been designed, and in numerous cases already made, has become so large that technical guidance to aid prospective buyers is very necessary. One American firm mentions that it found it necessary to make detailed technical studies of as many as twenty-eight different reactor systems before deciding on the best type for their immediate purpose. Much new development will naturally depend on the production of novel alloys by metallurgists and chemists, and on the choice of moderator and coolant most likely to assist in the attainment of the highest possible thermal efficiency of the plant as a whole. In this way, for instance, zirconium has been found especially promising because of its low neutron absorption, its resistance to corrosion, and its good behaviour at high temperatures. Hitherto a liberal degree of publicity has been given to details of reactor designs, but in future years industrial competition may delay the notification of some of the advances made until they have reached a fuller degree of perfection than sufficed in the immediate past. This is natural and is what has happened in many branches of engineering—even in those in which there are few complications arising through the need to employ such features as " bioligical shields " in order to protect the workers from possibly harmful radiations.

During the Geneva Conference an interesting announcement was made concerning the performance of the " Zephyr " reactor at Harwell, the first " fast reactor " to be built in Britain, having a core of plutonium in a matrix surrounded by an envelope of natural uranium. It was claimed that in this plant a ratio of plutonium breeding to plutonium consumption as high as 2 : 1 had been achieved—a promising result. A very attractive exhibit was the American " Swimming Pool " research reactor, briefly described in our issue of August 26th last. It takes its name from the fact that its core of enriched uranium is immersed in a pool of ordinary water, 10ft in diameter and 22ft deep, which acts as combined coolant, moderator and radiation shield, control being by the usual movable rods of boron. The much discussed Soviet reactor, which was shown in model form, represented the 5000kW power unit already built by the Russian Academy of Sciences. This was a pressurised water-cooled uranium-graphite reactor generating steam for a normal turbo-alternator plant.

As pointed out on the leader page of our issue of August 26th, the Geneva meeting amply showed that, despite all security barriers, the lines of thought and development run more or less parallel in the different parts of the world, and it has been clearly shown that nations have much to gain and little to lose by a free discussion of the problems that must be solved in order to exploit atomic energy for the ultimate benefit of mankind. Although the conference was concerned only with the civil uses of atomic energy, in many of the estimates of the costs of running civil reactors

credit was taken for the selling value of any plutonium produced, for which at present the only important buyers are those that need it for military purposes. The future of this market is liable to some uncertainty, whilst the use of plutonium for the enrichment of normal uranium for use in fast reactors or breeders is a market yet to be developed.

There is much to be said for a suggestion by Sir Christopher Hinton that manufacturers and users of civil reactors would be wise to begin with the better known types of reactors and that it is easy to be overventuresome. Later models, when they come, will no doubt prove to have a substantially better thermal efficiency ; indeed, some American manufacturers seem already disposed to gamble on this. Progress with the breeder reactors will certainly be watched with very great interest by all manufacturing countries ; their fuel may be a pure fissile material, whether plutonium or the light isotope of uranium (or thorium). But if and when they have been developed and had time to get into their stride, they should afford a steady and welcome output of substantially more fissile material than they consume. When this happens the market price commanded by such products as plutonium may well fall substantially.

The British Civil Programme

Apart from providing reactors at Harwell and its other establishments the British Government announced early in the year the considerable programme of construction of industrial reactors which was presented to Parliament in a White Paper (Cmd. 9389, summarised in our issue of February 18th last). British endeavour had previously centred on military needs, on its broadly based research and development programme, and on the production and distribution of isotopes for medical and industrial use. Now the effort is directed mainly at the employment of nuclear fission as a source of heat for supplying electric generating plant, and is intended to cover the needs of the next ten years, besides giving a provisional indication of the likely developments during the following decade. But it has to allow for modification as time passes in order to take advantage of such technical improvements as may appear practicable.

In this period of ten years the first two reactors to be built would be not unlike those in hand at Calder Hall (illustrated in Plate 1 facing page 8), whose reactors should begin to produce power by the end of 1956, and reach 92,000kW on completion, though their successors may well prove to have a somewhat higher efficiency.

They are designed to be gas-cooled graphite-moderated " thermal " reactors using for their fuel natural uranium, or possibly this in combination with a moderate enrichment of the lighter fissile isotope. Besides producing heat they will also produce a certain amount of plutonium which can be either used as a fissile fuel or passed to the military side for defence purposes. The next type is expected to be liquid-cooled and capable therefore of working at a higher temperature, and so have a substantially higher thermal efficiency. They may also make use of some of the plutonium already mentioned. This group should begin operating in about 1965.

All the twelve new stations proposed in the White Paper will be built for the C.E.A. by private industry with technical advice from the Atomic Energy Authority—which, however, as a research and development organisation, will continue with its function of building and operating pioneering types of power reactor. These stations are expected to have a total capacity of 1500MW to 2000MW, to cost about £300 million and to be ready in 1965. The Minister of Fuel and Power has since announced in Parliament that in addition to these twelve new stations it is hoped to add six more. These are to produce both fissile material and electric power.

The C.E.A. announces that the first two stations proposed to be built for their service are expected to be erected at Bradwell in Essex, and at Berkeley in Gloucestershire. The coolant medium is to be a gas which is passed to heat exchangers where steam for electric turbo-alternators will be generated. These stations are to have a capacity of between 120,000kW and 200,000kW and their construction is expected to begin in mid-1957, for power generation in 1960 or 1961. The intention is that a further two stations should be started by the close of 1958.

Apart from this White Paper, the public have had presented to them the first report of the U. K. Atomic Energy Authority covering its operation from its initiation in July, 1954, to the end of March 1955. An important point it makes is the limit imposed to its work, of scientific and technical development, by the lack of adequate staff owing to the sudden expansion of interest taken in this field by industrial firms. Similar shortages are being experienced in America—where the men at present available barely meet, it is stated, one half of to-days' requirements.

As to the more distant future it is hoped that thorium may also be used as a basic fuel and that " homogeneous " and " fast breeder " types of reactor will be further developed. When that happens the capital cost per kilowatt should be substantially less, and with a better thermal efficiency the cost per electric unit of power may prove to be little more than a half-penny per unit, and, therefore, compete with coal-fired power stations. On this programme the nuclear power stations should, by 1965, be able to meet one fourth part of the total need for new electric generating capacity, and to do this economically. Cheap power is much to be desired and the more rapidly this country can convert its generation to the most efficient system available the sooner will general costs of industrial production be lowered.

The original purpose behind the building of " fast " breeder reactors such as that at Dounreay was the fuller utilisation of fuel, and when that problem is successfully solved then it should be possible for an improved supply of fissile material to be obtained from natural uranium. To assist with this development the A.E.A. will construct at Harwell a low-power research model of the Dounreay reactor (of which the shell is now about half built, as illustrated in Plate 1, facing page 8), to be known as the " Zeus " reactor (zero energy uranium system). Its core will contain only fuel, canning material, and coolant ; there will be no need for any moderating material. The fuel will be uranium highly enriched with the light isotope 235 and one object will be to study how to produce plutonium with fewer of the engineering difficulties commonly found when power production is a simultaneous objective. A close practical study has been made of liquid sodium or potassium for service as coolant and it has been found that with them, or other liquid metals, it is possible to use a form of electromagnetic pump in which an electric current is passed across a pipe containing the liquid metal, which is placed between the poles of a strong magnet. The liquid metal flows along the pipe by the mechanical forces produced—much as happens in the motion of an ordinary electric armature. This form of pump has the very great merit of not needing any moving parts.

The main hazard to be faced in any nuclear power station arises from the unavoidable use of highly radioactive substances, though with meticulous care it can be kept within control—as is borne out by the health record of a great establishment such as Harwell. The disposal of radioactive waste products from the chemical processing plants is another problem, and great efforts are being made to find an industrial use for a portion at any rate of some of them. This proportion is likely to grow in the future; in the meantime the residue must needs be stored safely away from human contact.

The immense industrial interest now being taken in the civil employment of nuclear power became very evident towards the end of the year in the British Nuclear Energy Conference inaugurated by the Institutions of Civil, Mechanical, Electrical and Chemical Engineers with the support of the Institute of Physics, which held its first meeting at the Institution of Civil Engineers on November 30th, under the chairmanship of Sir Christopher Hinton. Seventeen speakers contributed to the proceedings and an audience of well over 1000 listeners endeavoured to find seats. One soon gathered from the proceedings how close now was the collaboration between the Atomic Energy Authority, the Central Electricity Authority and industry on future possible types of reactor. Each kind calls for special technologies, covering the appropriate fuel elements and the chemical processing facilities for the fuels selected. A full account of the Conference will appear in the January issue of its new *Journal*.

U.S. Atomic Energy Commission

We reviewed in our issue of April 8th last the seventeenth biannual report to Congress of the U.S. Atomic Energy Commission. This showed that the capital investment of that country in atomic energy facilities, which stood at 5000 million dollars at the close of 1953, had risen within the succeeding year to no less than 6200 million, largely as a consequence of the enlargement of the installations at Oak Ridge, Paducah, Portsmouth, Savannah River and Hanford. As a result of the recent revision of the charter of the Commission since its original enactment in 1946 there has been added to its task, of providing for national defence and security, a greater emphasis on the development of peaceful uses together with authority for increased international co-operation, in greater encouragement of private enterprise and in the spread of scientific and industrial information. This is a welcome addition to what is being done in other leading countries to further the use of atomic energy for civil purposes.

The current programme of the A.E.C. for industrial nuclear power development (all within four years) was thus summarised in its report :—

Type of reactor	Moderator and coolant	Fuel
(1) Pressurised water	Ordinary water	Enriched uranium
(2) Boiling water ...	Ordinary water	Natural and enriched uranium
(3) Sodium	Graphite-sodium	Enriched uranium
(4) Breeder	None/sodium ...	Uranium-plutonium alloy
(5) Homogeneous (uranium)	Heavy water ...	Enriched uranium solution
(6) Homogeneous (thorium)	Heavy water ...	U.233 solution

The third of these is of special interest, as it is to have an underground tank filled with liquid sodium, in which will be placed columns of canned graphite blocks to act as moderator. It can use either slightly enriched uranium, or perhaps a combination of thorium and uranium. In the homogeneous reactors the aim is that the fuel should be circulated in solution or suspension rather than in the form of rods ; this enables it to act as a heat transfer agent and to be cooled by some convenient liquid metal, such, for example, as sodium.

In October last the chairman of the Commission made the very important announcement that with a view to the discovery of a means to moderate and control the process of "atomic fusion," and so enable the lightest elements to be used as "fuel," five laboratories are uniting in a common effort, viz., Princeton University, New York University, and the A.E. Stations at Los Alamos, Oak Ridge, and Livermore ; research is especially directed towards the possible use of the heavy water, which is fractionally present in all oceans. This, if it succeeds, would indeed transform the world's energy supplies, but we must expect to wait awhile, perhaps ten or twenty years, to know whether it is really possible.

The lately announced discovery of yet another atomic particle—to be called the "anti-proton"—by the joint research work of the A.E.C. and the University of California, may have important consequences. Dr. E. O. Lawrence, the director of that University's radiation laboratory, is reported to regard this as "a milestone on the road to a whole new realm of discoveries in high energy physics that are coming in the days or years ahead."

The American A.E. Act of 1954 requires that the Commission should prosecute research and development in furtherance of its programme both in its own laboratories and by arrangement with outside institutions ; with this in view as many as ninety universities and other research institutions are being associated with the carrying out of the approved programme. On the engineering side, the Commission tells of the first atom-generated electricity used by a utility company being sent into the circuits of the Niagara-Mohawk Power Corporation on July 18th last. It is expected that during the next four years about £100 million of private funds will be spent on nuclear research and development ; and that over £2000 million is likely to be spent by the Government and industry on reactor construction, calling perhaps for an annual supply of some 8000 tons of natural uranium.

The United States has lately agreed with twenty-three other countries that with a view to assisting them in nuclear research and its peaceful developments it is willing to lease up to 6kg of U.235 (contained in material enriched to a maximum of 20 per cent) and to receive the spent fuel elements for reprocessing in U.S.A. The U.S. Government also undertakes to pay half the cost of any research reactors bought from a certain number of American manufacturing firms.

The eighteenth half-yearly report of the Commission was fully reported in our issues of October 21st and 28th last, and included an important, though brief, reference to "Operation Wigwam," conducted in the Eastern Pacific Ocean in the middle of May, of which the chief purpose was to study the effects of a deep under-water detonation of a nuclear charge. The possible bearing of this investigation on an extension of present methods of anti-submarine defence needs no emphasising—not least in relation to the defence of the British Isles. The first nuclear U.S. submarine, "Nautilus," proceeded for the first time under its own power in January, 1955 ; a second submarine, the "Seawolf," was launched six months later and its engine has been put through preliminary tests on land. Apart from the continuation of work on nuclear submarine construction, involving, according to press reports, six more submarines being ordered for the U.S. Navy, the American Government has also concerned itself through the Commission with the development of nuclear power for other mobile plants, e.g. the study by the Baldwin organisation of its application to railway locomotives, and to further work in its possible use in aircraft. On this latter point Dr. H. L. Dryden, the director of the National Advisory Committee for Aeronautics, is reported as informing a Senate Committee that : "There are undoubtedly going to be nuclear engines for airplanes." This prospect, however, may lie in the "foreseeable future," rather than the immediate present.

In a letter from the Institute of Nuclear Studies at Chicago University, published in the September issue of the *Bulletin of the Atomic Sciences*, it is reported that the one-time fear of "subversion" is happily growing somewhat less and that a "more rational atmosphere respecting individual rights is taking its place." Even so, it does read oddly in the very same journal to learn that a professor at the California Institute of Technology has been barred by the Defence Department from "further work on secret projects which he originated" and this on the ground that, although he has lived in the U.S. during the past thirty-one years he has retained his Swiss citizenship !

An important topic in American news during recent months is the appearance of the first price list ever issued for the sale of uranium and heavy water. On August 8th Admiral Strauss announced that for normal uranium metal the price would be 40 dollars per kilogramme, and for heavy water (for use as moderator) 28 dollars per pound. It seems, moreover, that in any international gifts of uranium, metal previously enriched with a certain amount of the fissile isotope would have that proportion limited to 20 per cent, so that there should be little temptation to divert any of it to warlike use.

As regards the plutonium supply the *Economist*, in its issue of July 23rd, published a warning of the possible effect of the very large U.S. output for military purposes. How large this may be is not revealed but Mr. Gordon Dean, former chairman of their A.E.C., is reported as saying that before long the U.S. "will have atomic bomb material (mainly plutonium) running out of its ears !" There is it seems a natural limit to the size of the stock-pile of atomic weapons that even the U.S. can desire. Hence it may well be that countries buying atomic reactors will be able to obtain plutonium fuel on advantageous terms, a consideration which they will no doubt bear in mind. At the moment the initial fuel charge for a nuclear power station has been put at about £5,000,000. The same journal also points out that during the last twenty years British coal has risen steadily in price in relation to other commodities, and that the cost seems likely to rise no less rapidly in future. Hence the pathway for the steady introduction of nuclear power stations should be the more easy. In the British Government White Paper (Cmd. 9389) the probable cost of nuclear power was put at some 0·6d. per unit (much the same as that from the modern coal-fuelled stations) so that even if the selling price of any plutonium also produced should fall, a not impossible increase in thermal efficiency of nuclear operation might still enable the atomic energy stations to remain competitive.

Waste Products from Reactors

Nuclear reactor plants, like many other industries, have the problem of disposing of their waste products, but in this instance more than usual difficulty is experienced because of their dangerous and toxic character and not less because there has been so little time in which to find auxiliary industrial processes for their useful employment. At present, the simplest, though very wasteful, procedure is to dump them in special storage tanks, or even in some cases in the ocean. This is a problem which needs the urgent attention of the chemical profession. Hitherto nuclear problems have been generally looked on as the special task of the physicist and engineer, whilst the extent to which the chemist is needed has not been sufficiently appreciated. But it is estimated that the production of plutonium from natural uranium reactors calls for the service of more chemists than engineers and physicists put together ! However this may be, the need now is evident for an energetic attack on the problem of how best to employ the special qualities of some of these waste products in large-scale industrial processes. The first uses to be found related to medical investigations for therapeutic treatment and as tracer elements ; later came the industrial uses in the plastics industry, in the study of the nature of frictional wear, of improvements in transistor construction, of thickness gauging, of leak detection in pipelines and other forms of water flow. Suggestions have also been made to use them for the polymerisation of ethylene, for the sterilisation of chemical products and in the preservation of some kinds of food (even the possible conversion of wood to provide digestible material for ruminant animals). No doubt other modes of employment will be found in due course, but it is much to be hoped that the process will be hastened so as to catch up with the rapidly growing increase of such products that has to be faced. In so far as such discoveries are capable of being used on an industrial scale and prove to be financially profitable in practice, by so much will the cost per unit of power production be reduced; but whilst such possibilities are under trial it is hardly to be expected that all discoveries will be at once broadcast, since some of them may be reserved for publication until the possible need for patent protection has been properly considered.

Warheads for Missiles

Various indeed are the types of missile proposed for use in military equipment. But massive as some of them have become, the increase in the power of the warheads they carry has reached still more startling proportions. Whereas in the early days of the first world war a bomb carrying little more than 50 lb of T.N.T. and fitted with a delay fuse was in common use for submarine attack, by the close of the second world war the charge carried by a single bomb had reached the astonishing equivalent of 20,000 tons of that explosive. And to-day, judging from Press reports, the figure has reached as much as 20,000,000 tons ; indeed, it has proved necessary to invent a new unit of explosive power, the "megaton," representing the explosive power of 1,000,000 tons of T.N.T.

In some of the investigations which the Nevada Proving Ground lately undertook, there were tests made, in the presence of

American, Canadian and British experts, with an anti-aircraft missile of unprecedented capacity. Its explosive power at 30,000ft altitude was estimated as being as much as a third of that of the Nagasaki bomb of 1945, and large enough, it was judged, to destroy all formations of aircraft within half a mile of the point of detonation. From this, it would seem that pilot-operated aircraft may in future have a much less good chance of survival. Such considerable changes naturally make it of interest to engineers to consider the means by which so huge a development could take place. But for security reasons such information as is allowed to be published is limited in scope, and varies moreover from country to country, though in America it does appear that more importance is now given to the idea that the "locking of doors" may sometimes shut out more than is kept in! Certainly the famous American "Smyth Report" (published in 1945) brought to the knowledge of the world the first authoritative account of the physics of the uranium bomb, and though there has been no comparable publication of the working of the thermo-nuclear bomb, a certain amount of matter has now been allowed to be published. It is true that such disclosures are not made the easier to follow by the strange terminology commonly in use: nuclear bombs based on uranium, plutonium or thorium are commonly called "atomic bombs"; but those using instead the atoms of hydrogen and lithium are "hydrogen bombs," unless they happen to have their casings made of cobalt, when they become "cobalt bombs"—a term formerly in use to describe the use of a cobalt isotope for "radiating" hospital patients under treatment for internal diseases such as cancer! Whilst in the latest suggestion (as revealed perhaps at some 1954 tests at Bikini) an H-bomb could be encased in a thick shell of ordinary uranium with the result, it is stated, of increasing its power forty-fold, i.e. well into the megaton range.

These considerable developments naturally present a most complex problem to those in charge of defence requirements in all countries. The armed forces of the future may, it seems, take the following very different forms:—"conventional armaments" depending mainly on manpower; "tactical weapons," such as the small atom bomb carried in aircraft or in the various guided missiles and in some forms of artillery, and a third, of major power, the "megaton weapon." Although this last is sometimes regarded, rather fearfully, as a device for "mutual suicide" by all who use it, nevertheless time may yet prove it to be, by its very deterrence, one of the most effective guardians for peace that the world possesses.

Aeronautics in 1955

Civil Aircraft

THE annual display of the Society of British Aircraft Constructors at Farnborough in September was graced by two new aircraft for commercial operators, the Handley Page "Herald" and the Scottish Aviation "Twin Pioneer." (Plate 11.) The former, characteristically a British airliner in appearance, will bring four-engine safety and pressurised comfort to shorter routes and lighter traffic than formerly; the "Herald" should prove to be able to use undeveloped airfields. The engines of the "Herald" are Alvis "Leonides Major" fourteen-cylinder radials with single-stage supercharge and poppet valves with optional braking airscrews. The concept of the aircraft is classical, but the construction unusual. As with the wartime Handley Page aircraft, the airframe is divided into a large number of subassemblies, allowing the maximum number of men to work on one aircraft. The "Herald" employs a technique of construction that allows the outer skin panels to carry a great deal of the structural loads; the skin is formed to the required contour and placed in a jig, and a corrugated sheet laid on the inside. In the case of panels with cylindrical or conical curvature the corrugated sheet does not have to be preformed. The crests of the corrugations are then united to the skin by spot welding, an advanced technique of preparing the sheets and inspecting the welds rendering this process acceptable for primary structure. The curvature is then locked into the panel by placing an inner skin on the corrugated core, drilling through where it rests on the core, and attaching it by blind riveting. These panels have an accurate and stable outer surface and a smooth inner surface which is particularly convenient for tank bays, luggage compartments, and so on. On the wing leading edge the channels in the core are used to conduct hot air for de-icing.

The Scottish Aviation "Twin Pioneer" is intended, like its predecessor the "Prestwick Pioneer," to couple the ability to use very confined airfields with the relative cheapness of a fixed-wing, piston-engined aircraft. By making generous use of high-lift devices, such as have been in use for many years, it is possible to attain cruising speeds that would be very costly with a helicopter, while not requiring an aerodrome out of all proportion to that which would be needed for regular all-weather helicopter services. The initial cost of the machine reflects the absence of rotor drive and pitch control mechanism, and of heavily loaded aerofoils subject to continuously fluctuating stresses. Like most of the machines known as "Gugnuncs" after an early successful wide-speed-range aeroplane, the "Twin Pioneer" is a high-wing braced monoplane with a large ground angle and very generous tail surfaces for low-speed flight. It carries sixteen passengers, or 3000 lb of freight, 600 miles in five hours on 1150 lb of fuel, to give one example of its performance.

A trend can now be observed for the high-revenue air routes to pass to turbine-powered aircraft for progressively increasing stage lengths. The Vickers 700 "Viscount" is still in eager demand, and more powerful versions of the "Dart" are promised for the "Viscount Major" 800. A projected successor, the "Vanguard" 900, will have an operational range extending up to 2500 miles. However, in November it was announced that the Ministry of Supply order for six Vickers 1000 transports, fitted with Rolls-Royce "Conway" by-pass engines, had been cancelled because the aircraft did not promise to provide the required performance. A related project, the "V.C.7" airliner, capable of flying from Great Britain to the U.S.A. summer and winter, was reconsidered and discarded on the grounds that the British Overseas Airways Corporation would not require it at the time it would become available. Different views were held in other quarters; later it was suggested that the next British jet airliner should be designed for sustained sonic speeds. There were not wanting those who contrasted the gradual evolution of the Vickers propeller-driven airliners with the mutation suggested from conservative machines to one more ambitious even than military aircraft.

Meanwhile, a de Havilland "Comet III" has been built and flown as a precursor of the "Comet IV." Numbers of Bristol "Britannias" are under construction at Bristol and Belfast, and two have been delivered to B.O.A.C. A successor for the "Britannia," to give even longer ranges at speeds currently associated with jet aircraft, is now being studied jointly by Bristol, whose B.E.25 "supercharged" turboprops will power it, the Convair Division of the General Dynamics Corporation, and Canadair, Ltd. Since the British and United

Fig. 1—The Handley Page "Victor" bomber is intended to follow the "Valiant" into service with the Royal Air Force

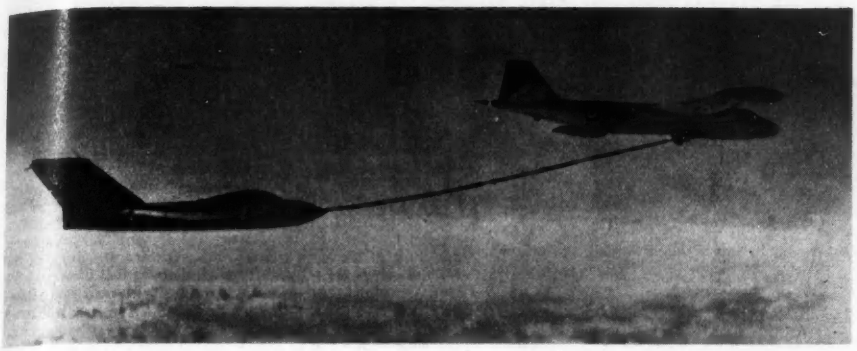


Fig. 2—The Gloster "Javelin," seen here refuelling from an English Electric "Canberra" bomber, is now ready for service as an all-weather fighter

States participants in this partnership have built the largest land-planes in their respective countries, a vast fund of experience on propeller-driven aircraft is available to them.

Convair is also participating in an even longer-term project: one of the hundreds of their great six-engined "B.36" machines has been modified to carry an atomic reactor aloft, principally for tests on the shielding. At a Conference on Atomic Energy in Industry in New York* the construction of an atomic-powered aeroplane was discussed, and it was pointed out that weight—a shielded reactor might weigh 50 tons—would prevent the pile being completely shielded, and only in the crew and radio compartments would a low level of radiation prevail. Thus, the machine would be confined to completely isolated runways of great length: once the fission-powered machine was well established this would be unimportant since the negligible fuel consumption would allow very few landings to be made. However, in the experimental stages a flying-boat would have immense advantages. Here, perhaps, we see an application for one of the Saro "Princess" machines, which are still awaiting economically attractive power units: the manufacturers believe that the Bristol "B.E.25" would prove suitable. However, it may be that the big flying-boat will remain in desuetude until the vulnerability of aerodromes in time of war, and the cost of providing them for increasing numbers of noisy aircraft, call for a multitude of dispersed airports. It has been suggested† that aircraft carrying nuclear reactors might, for safety reasons, be restricted to flying over the sea.

At the opposite end of the scale, some distinctive small aircraft have resulted from the ability to dispense with an airscrew. Numerous early ultra-light aeroplanes had propellers mounted above the fuselage; with jet propulsion the engine can very readily be located on or near to the centre of gravity. An example of this technique is the Somers-Kendall aircraft illustrated on Plate 11, which clearly reflects the designer's experience with high-performance sailplanes. Another trainer with a similar engine mounting but this time a side-by-side two-seater with conventional landing gear and tail surfaces, is the Miles M.100 "Student," the prototype of which is expected to fly in 1956. We digress to observe that during this year the first group of Royal Air Force trainees to be instructed *ab initio* on jet aireraft passed out: they flew Hunting Percival "Jet Provosts," a "Viper"-engined version of the "Provost" retaining the tail-wheel undercarriage.

The helicopter is continuing to progress towards the predicted economic load of forty to sixty passengers. Nearing completion is the prototype of the Hunting Percival "P.74," whose rotor will be driven by tip jets supplied with hot gas by a pair of 750 h.p. Napier "Oryx" gas generators. The S.B.A.C. flying display included demonstrations of the transition from powered lift to aerodynamic lift by the Fairey "Jet Gyrodyne," but the "Rotodyne," illustrated in our aeronautical review of January 8, 1954, is still awaited.

Military Aircraft

Due to their immense cost, few types of military aircraft are built in Great Britain to-day. The Hawker "Hunter," now established in squadron service, is officially regarded as the best interceptor in service in Europe. It is intended that it shall be superseded by armed versions of the English Electric "P.I.," another swept-wing aircraft, and the Fairey "Delta 2." However, there is in hand at Saunders Roe, Ltd., an interceptor powered by both turbo-jet and rocket engines, on the lines of the Sud-Ouest "Trident" or "S.O.9050," in France. The Folland "Gnat," sole representative of the light jet fighter, may be put into production in India. The Gloster "Javelin" all-weather fighter is now ready for squadron service. Of the "V"-series bombers, the answer to our question twelve months ago is that, in order to obtain the maximum offensive strength in a short time, all three will be put into production; only the "Valiant" is at present operational.

One novel machine to appear this year was the Fairey "Ultralight" helicopter. Designed for tactical reconnaissance and other short-range missions with the Army, it can be carried on a 3-ton truck and manhandled on the ground. Burners at the tips of the two rotor blades are supplied with compressed air by a Blackburn Turbomeca "Palouste"; the exhaust gas provides an element of thrust and allows control in yaw by means of a simple rudder (see Plate 10).

Research and Engineering

Great interest was aroused during last year by the publication of discoveries and techniques that have for some years lain under security classifications. One such was the use of free flying models, incorporating or launched by rockets, for aerodynamic research at supersonic and trans-sonic speeds.‡ The models were equipped to measure, as required, such quantities as acceleration, local pressure, angle of attack, and forces between parts of the vehicle, and transmit the information to the ground by radio. Other equipment gives a continous record of the position and attitude in roll of the machine; by differentiation of the records, such significant parameters as drag, aerodynamic damping, and control derivatives can be obtained. Each model was accelerated from rest to a supersonic speed—say, a Mach number of 1·5—and then coasted to the ground in a shallow trajectory; the time of flight was perhaps twelve seconds and the length 4 miles.

One particularly interesting application of this technique was to check the basis of the "area rule,"§ which was derived from wind tunnel tests at trans-sonic speeds in the United States. Three models of identical length and volume, illustrated in Fig. 4, were

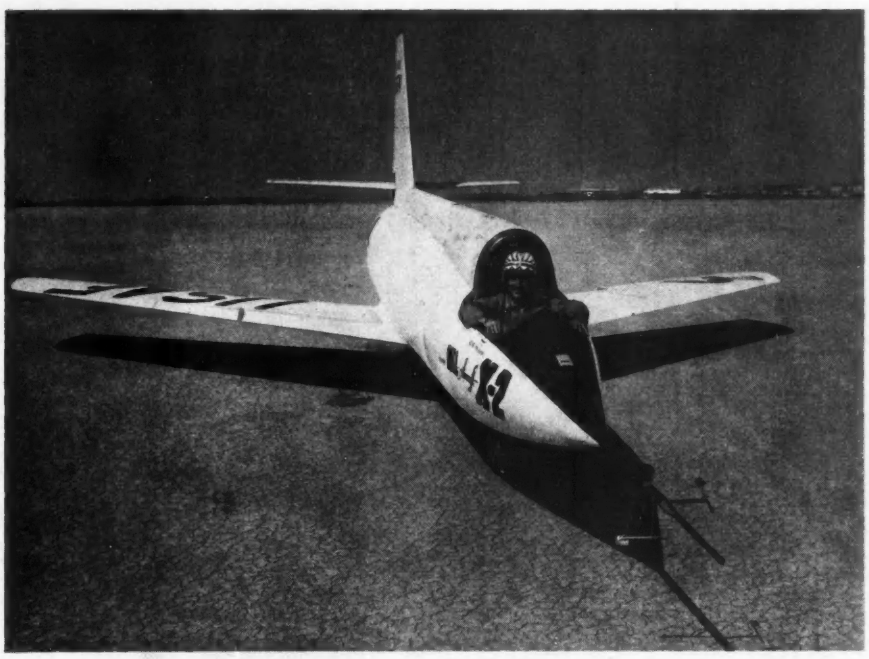


Fig. 3—A significant first flight, late in 1955, was that of the rocket-powered "Bell X-2," which dropped from a Boeing "Superfortress" and landed at Edwards Air Force Base, California. The pilot was Lieut.-Colonel F. A. Everest, U.S.A.F., seen with the aircraft on the dry lake that is the flying field

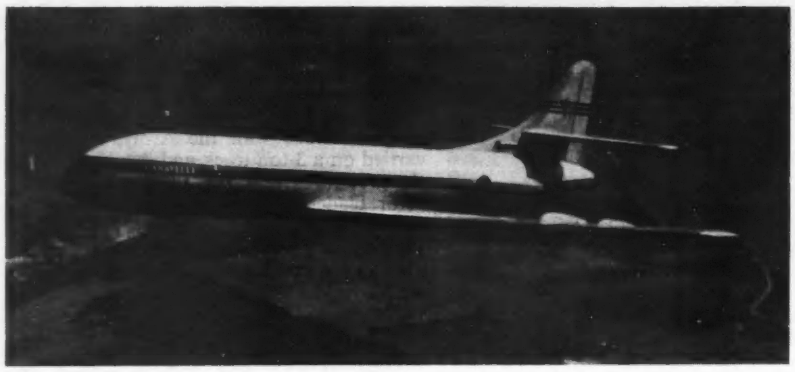
* *Aviation Week*, October 31, 1955.

† David Keith-Lucas, Lecture to the Belfast Association of Engineers, March 2, 1955.

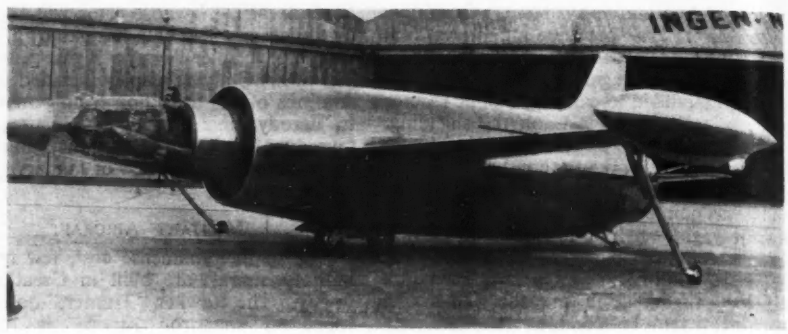
‡ J. A. Hamilton and P. A. Hufton, lecture to Boscombe Down Branch of Royal Aeronautical Society. December 1, 1955.

§ N.A.C.A. Research Memorandum L52H 08.

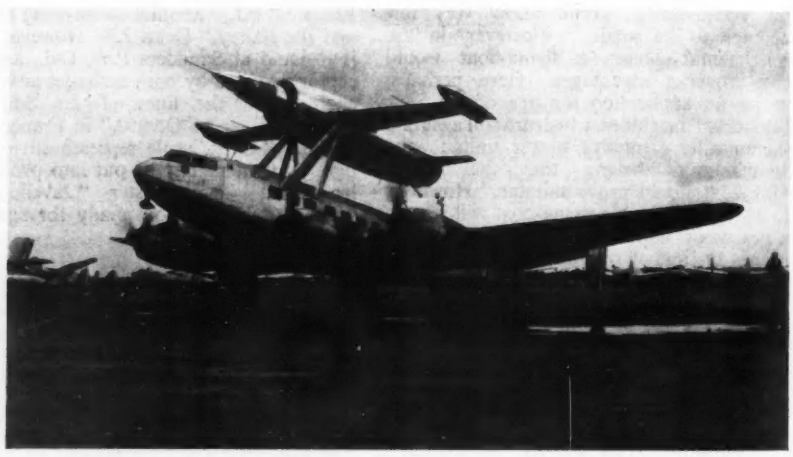
FOREIGN AIRCRAFT OF 1955



The first French jet airliner, the S.N.C.A.S.E. S.E.210 "Caravelle," has two Rolls-Royce "Avon" engines: their location eases control difficulties in the event of engine failure at take-off. The passengers enter by a retracting stairway under the fuselage, slightly behind the engines, and the cabin is in front of the nacelles. The fuel is carried in a torsion box that includes upper and lower skins over about one-third of the wing chord; the rearward mounting of the engines brings the wing so far back that the fuel lines pass the cabin in a duct only a foot or two long. The wing has flaps, dive brakes, and a "droopable" leading edge; it carries the main legs of the undercarriage, the bogies retracting into the wing root. Up to ninety-one passengers can be carried, and stage lengths of over 2000 miles can be flown



An important event at the 1955 International Paris Salon was the first public demonstration of a ram-jet aircraft. The "Leduc 021" is launched in flight from its modified S.N.C.A.S.E. "Languedoc" carrier and then lights up to fly under power. The nose section, which includes the cockpit, can be jettisoned, and the transparent sheath moves forward to give access. The main part of the body, together with the nacelle, form an annular diffuser, and behind the nacelle a set of vortex generators stabilise the flame behind the fuel sprayers. In the rear of the nacelle a Turbomeca "Artouste" provides power for the fuel pumps and other auxiliaries, while the exhaust initiates combustion in the propulsive duct. The layer of air immediately within the wall remains unburnt to keep the structure as cool as possible. The pressure inside the body is the principal factor limiting the design performance; the aircraft illustrated has a diameter of about 8ft and can reach a Mach number of 0·85. Ram-jets are, of course, only efficient at supersonic speeds, and the "Leduc 022" fighter now under construction will probably attain Mach 2 at altitudes exceeding 50,000ft. This machine will be able to take off under the power of a turbo-jet engine. Aircraft of this type were proposed by Monsieur Leduc as long ago as the 1938 Paris Salon, and the first successful ram-jet flight was made in 1949 with an aircraft built mainly before the second world war



One of a variety of vertical take-off aircraft that have recently appeared is the McDonnell XV-1 "convertiplane." It is reported that on its first flight this machine flew at 180 m.p.h., well in excess of the recognised helicopter speed record. In our illustration it is seen in the powered-lift condition with the propeller at the rear of the nacelle stationary; the engine, an air-cooled "Continental," is driving the compressor delivering air along the rotor blades to the burners at the tips

used. The first was a body of revolution whose shape was theoretically that to give minimum sonic wave drag for certain fixed values of length, base area, and volume (these were determined by the need to accommodate an internal rocket motor); for the second model a wing was chosen—arbitrarily—with an untapered 50 deg. swept planform and biconvex sections, and to this was added a body of the same length and base area as model "A," but so shaped that the total volume (wing+body) and the combined

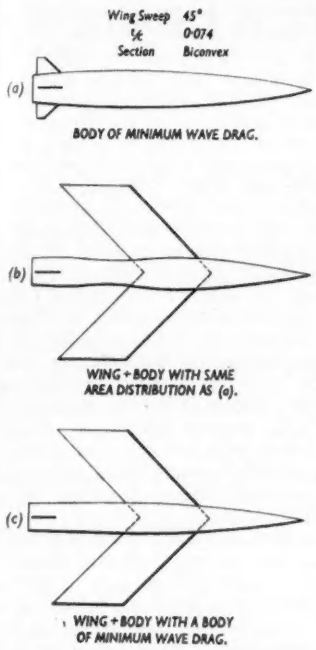


Fig. 4—Free flight models for study of the area rule

(wing+body) cross-sectional area distributions were identical to those of model "A"; the third model had the same gross wing as model "B" and the same values of length, base area and total volume as "A" and "B," but the body shape was such that the wave drag of the body alone was a minimum at sonic speeds. That is to say, if the component drags of "B" or "C" are considered, the wing drags are equal, but the body drag of "C" is less than that of "B." According to area rule, however, the sonic wave drags of "A" and "B" should be equal and less than that of "C." The trends indicated by the theory are closely confirmed by the experimental drag curves (Fig. 6).

These results demonstrate also that drag tests on components of specific aircraft designs may be valueless and that the only reliable test is one on a complete model of the aircraft. This can be done using the separating model technique, and in the most striking example of the efficacy of the area rule, the Convair "F.102" delta fighter, this was in fact done. The "F.102" was originally designed with "conventional" aerodynamic contours, but proved to have an excessive drag rise above Mach 0·9. The area rule was applied to obtain a total cross-sectional area distribution close to that of the theoretical minimum drag body of revolution, with the result that, as the delta leading edge swept out, the width of the fuselage gradually diminished, while behind the trailing edge bulges were added to the fuselage. Models of the two versions were launched by large booster rockets and, with the successful flight of the full-scale "F.102A," the value of the rule was demonstrated. It will be seen from the graph that there is a marked departure from the theory above M=1·01, and in fact the simple form of the rule applies only at Mach 1. The ideal shape is different at different supersonic speeds, and an aircraft designed for the highest possible maximum speed will not have the lowest drag rise in the trans-sonic region.

Other theories having a different theoretical basis have been developed for the design of high-speed aircraft, but are not yet public knowledge. However, it is now possible to appreciate more fully the shapes that these aircraft assume; where the wing occupies a comparatively short length a waisted fuselage results, while the parallel section of the great part of the fuselage of the English Electric "P.1" is seen to be consistent with the cross-sectional area of the wing increasing gradually along the root and then diminishing to the tips, nearly opposite the tail. In aircraft with air intakes for gas turbines, the internal flow must also, of course, be taken into account.

Another application of supersonic theory is the athodyd, or ramjet. This type of aeroplane appears in its most advanced form in France, where a Leduc development machine was publicly demonstrated this year (see page 14). This system of propulsion has led to the formulation of designs for coleopters, or annular wing aircraft, which might climb vertically at Mach 1 and attain Mach 2 in level flight, and a pulse-jet coleopter has been flown by S.N.E.C.M.A.

A vehicle built to test this system of propulsion was revealed in Great Britain at the National Gas Turbine Establishment, which is conducting both free flight and rig testing of athodyds. This Napier ram-jet has fixed fins at the tail and therefore flies in the zero-lift condition as a projectile; it is launched by a group of solid-fuel rockets which fall away at all-burnt, by which time the speed of the vehicle is high enough for the aero-thermo-dynamic duct to light up. Three years ago, in our annual review, we illustrated a Bristol ram-jet in flight; this form of propulsion is being developed for guided missile purposes by Bristol Aero-Engines, Ltd.

Other ideas for the integration of the thrusting and lifting systems of the aircraft have been put forward. One which was published recently originated at the N.G.T.E. and sought to make the fullest use of the immensely powerful jet efflux of a modern high-speed aeroplane. The suggestion was, basically, that the jet should issue downwardly from a slot running along the trailing edge of the wing; intuitively, it can be accepted that the effect on the air stream will resemble that of a small flap when the aircraft is flying fast and a large one when the air speed is low. Wind tunnel tests have shown that, in fact, the jet flap can offer lift coefficients far beyond those possible with any system of fixed aerofoils, so that short runways for fast and heavy aircraft become an attractive possibility. The characteristics of a jet-flapped wing differ so markedly from the normal that conventional stabilisers and controls may not appear on an aircraft with this flap; the wing would probably be unstallable, while a full range of lift coefficient could be obtained at or about zero incidence. While many of the problems of this development are expected to be amenable to wind tunnel investigation, the evaluation of the drag of the system is at present controversial, and an acceptable account may await free flight trials.

While the jet flap offers a prospect of greatly reduced landing speeds, if control difficulties do not prove prohibitive, vertical take-off is being striven for in many cases. Helicopters are now established and accepted for many purposes, but their poor

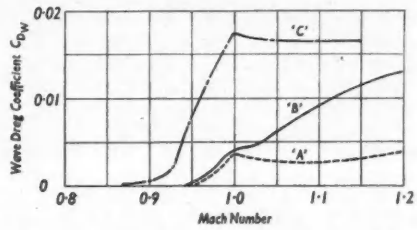


Fig. 6—The effect of area rule application on wave drag

cruising performance offers ample opportunity to competitors. For military purposes, where aerodromes are not available, the United States have flown fixed-wing, propeller-driven aircraft with a sea level static thrust exceeding their own weight, taking off from an attitude erect upon their tails. Ryan Aeronautical Company has now built such an aircraft with Rolls-Royce "Avon" jet power. In France, the Breguet "941" is intended to take off with no ground run by deflecting the slipstream of four airscrews by means of immense flaps extending down from the trailing edge of the wing, and a similar project has been flown in model form in the U.S.A. In Great Britain, the Ministry of Supply has ordered a vertical take-off machine from Short Brothers and Harland under the denomination "P.D.11."

These varied extensions of aerodynamic theory have been accompanied by many fresh developments in aircraft engineering.

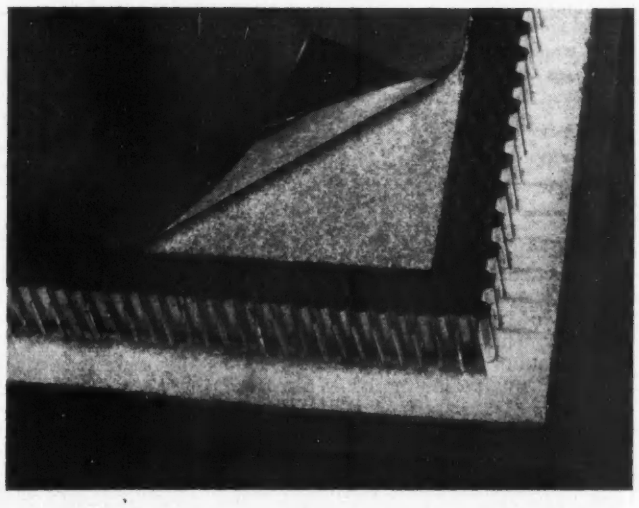


Fig. 5—Increasing flight speeds lend emphasis to the need for stiffness in aircraft structures, and sandwich constructions are one solution to this requirement. This demonstration honeycomb is bonded with "Redux"

Power-operated flying controls are now an accepted practice among high-performance and heavy aircraft, and many of them take advantage of this to dispense with direct mechanical connections between pilot and control surfaces, ensuring safety by means of

multiplication either of servo motors or of control surfaces. In aircraft where the general arrangement welcomes a conventional control run, a power-operated system similar to a servo-assisted installation can be used, with the mechanical system acting as a standby. One example of this method, which was displayed at the S.B.A.C. exhibition last year, was the Elliott-Hobson integrated flying control system, in which the hydraulic servo motors accept signals not only from the pilot, but also from the automatic pilot and the auto-stabiliser. Backlash is provided in the control run, and artificial feel is fed back to the control column. If the pilot induces a "feel" of magnitude that would endanger the aircraft, the power system declutches, calling for a greatly increased effort by the pilot. The auto-stabiliser also feeds signals to the hydraulic motor; these are limited in amplitude and the control column does not "feel" them. When the automatic pilot is engaged, the backlash is locked solid, and the column follows all control movements; in this condition, the aircraft can respond to the pilot's commands through the miniature stick and to the demands of systems governing instrument approaches, weapons aiming, or course following. In the auto-pilot condition there is again a limit to the acceleration that can be applied to the aircraft, so that a run-away of the power system should not be catastrophic. A trimming device underlies the artificial feel, so that the stick force in steady flight is always zero, and the automatic pilot is not limited to those control surface movements which would be safe if applied suddenly. There is perceptible a strong trend to introduce systems of this nature and such devices as approach couplers which fly the aircraft down the instrument landing glide path; thus the pilot becomes a supervisor of the aircraft's actions in contrast to being a slave ministering to its needs.

The airframe itself is also changing: skin and stringer constructions are suffering increasing attacks on account of their cost and complication, poor aerodynamic contour and limited stability. Alternatives that are finding favour are various sandwich constructions with metallic or organic cores, fabrications in magnesium with greatly increased moduli for the same weight, and even, in some cases, mouldings in cured plastics. High-speed aircraft are demanding aerofoil sections and stiffnesses that can only be met by milling from solid metal, and the machines that are furthest forward in the "thermal thicket," such as the Bell "X-2," are already substituting stainless steel for titanium alloys.

An engineering development that promises to influence aircraft operations considerably is the hydro-ski. Here the aircraft planes on the surface of water on a small ski which can be made retractable or even added to a wheeled undercarriage, though in this case the machine has to keep taxi-ing until it is beached. This enables the conventional planing-bottom hull to be drastically modified: the drag penalty normally associated with a water-based aeroplane is eliminated and, in addition, operations become possible in heavier seas. This technique has been applied to a jet fighter, the Convair "Sea Dart"; this machine has tried out various ski configurations but is not at present flying. Hydro-skis have been applied to the "panto-base" Stroukoff "YC-123" transport to allow it to operate from runways, water liquid or frozen, or unprepared soft ground: sealing of the freighter's hull allows it to float.

One aspect of aeronautical engineering that has emerged into prominence in this country is the disproportionate difficulty encountered in getting a new aircraft from the prototype to the state of productive flying. One view is that this is inevitable because the changing weather of the United Kingdom forbids a planned flight-testing programme. However, it seems highly possible that there may be a pronounced shortage of engineers capable of the exacting exercise that is the development of a modern aircraft, if only because so few aircraft are carried through this development process by the industry. There is now in session one in a series of annual conferences intended to assist production engineers to speed the output of aircraft. If a similar approach were made to ease the development bottleneck, one assertion could be made: the development histories of many machines would be sagas of absorbing interest and vast value.

Shipbuilding and Marine Engineering in 1955

No. I

IT may be remembered that during the first nine months of 1954, shipowners virtually took a holiday from ordering ships and that such orders as were placed were, to all practical purposes, offset by cancellations of what may be called tentative contracts. However, this slowing down of tempo was reversed in the last quarter of the year, and the final total of orders for 1954 exceeded 600,000 gross tons. Nevertheless, there was a distinct running down of the order book to a total of 770 ships, representing about 4,300,000 gross tons. Although this figure must inevitably be compared with the rather unreal peak total of 7,000,000 gross tons reached in 1952, however, the shipbuilding industry, with orders worth £500 million on its books, could not be rated other than prosperous.

This description can be applied with perhaps greater emphasis to the industry for the year 1955, since the flow of orders which began late in 1954 continued and even increased in volume during 1955. Some eighty ships of 270,000 tons were ordered in the first quarter and the total at the end of the second quarter stood at 157 ships of 520,000 tons, while 109 ships representing 846,000 tons were ordered in the third quarter. This revival in the placing of orders was confirmed by the state of the order book at the end of the year, when the estimated total stood at some 800 ships of approximately 5,000,000 gross tons and valued in round figures at £625 million, of which about 24 per cent represented the value of orders for foreign flags. Such a total represented conditions which are very far removed from those normally associated with the industry between wars. It was noteworthy that the orders placed during the spring and summer were for a wide variety of ships, representative of the diverse activities of our shipowners in the world of sea transport, and that oil tanker tonnage represented a much smaller percentage of the total than usual. This was remedied towards the end of the year, when the oil tanker companies, having assessed the future demands for oil for the production of electricity and for industry, in relation to the tonnage of their fleets, announced large building programmes, which included ships of large deadweight capacity. Although the oil tanker tonnage helped to raise last year's orders to a high figure it must not be forgotten that ordering on such a large scale will not be repeated again for several years. Another point of interest in the 1955 contracts was that the orders placed were nearly all for British owners and that the tonnage placed compensated for the reduction in orders from foreign buyers.

Although oil tankers continued to occupy a prominent place in the order book the overall intake of orders at approximately 2,000,000 tons gross preserved a reasonable balance between the various classes of ships so that all yards participated to varying degrees. Since no large naval vessels were under construction in private yards, the ordering of super-tankers meant that the larger berths were occupied to advantage. With production running at 1,500,000 gross tons per annum, the work currently in hand and to be laid down represented full employment for roughly four years; however, this is only an average figure and, it must be emphasised, was not representative of the whole industry, many firms being able to quote a much shorter time for particular classes of tonnage.

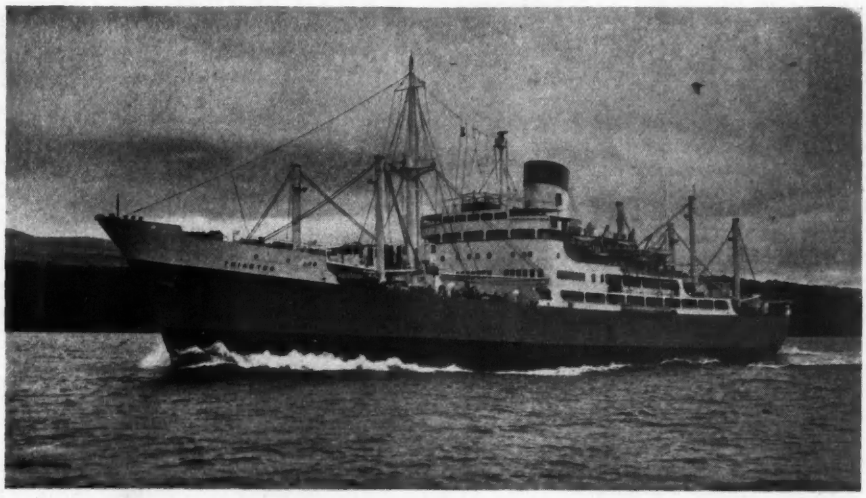
That there was a reduction in orders from foreign customers was not unexpected; only a little more than 20 per cent of new orders were for export, since each year has seen more berths brought into operation abroad. With the greater availability of building slips and other inducements, foreign owners not unnaturally placed orders with their national establishments and, indeed, British owners ordered ships abroad because of the fixed prices offered and the early delivery dates. These twin conditions were not a possibility in British yards, but they offered a strong incentive to order tonnage, since the owner was aware of his financial commitments when placing the order, and combined with that knowledge he knew that his ship would be earning dividends on the capital invested within a short period of time. Inevitably, as orders were placed in continental establishments, the very conditions which attracted them gradually disappeared and foreign builders found that the back log of orders on their books extended delivery dates, and no longer allowed fixed prices to be quoted. Another point was that any gap between shipbuilding costs in British and German yards would be narrowed by increases in wages and reduction in working hours in the German heavy industries. The oil industry placed many orders for tankers with continental builders and this helped to bring about the state of affairs in which continental yards were placed in much the same position as British builders in the matter of tendering and delivery dates.

It is essential to weigh carefully the pros and cons of this question of orders going abroad, for the loss of an order from a continental owner has its compensations, although it is essential to our shipbuilding prosperity to continue to build for foreign owners. However, just as it is of more value to export steel in the form of a ship, then a ship built for a British owner may be of more value to our economy than a ship built to foreign account. The export ship represents a single cash transaction, whereas every additional unit in our merchant marine

represents an annual increase in the country's invisible earnings, during the life of the ship, and has a residual scrap value.

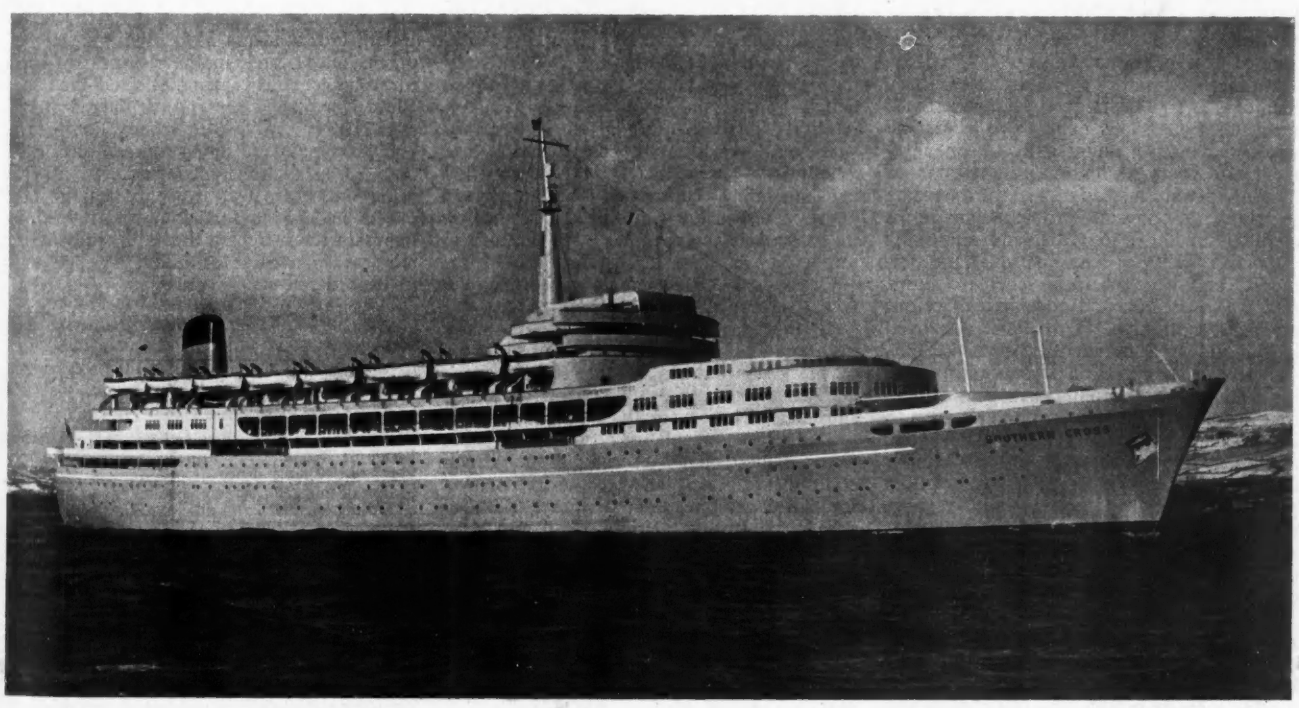
The total of steamships and motorships under construction in this country at the end of September, the latest date for which figures are available, as recorded by Lloyd's Register of Shipping, was 2,147,000 tons gross, or approximately 90,000 tons more than at the same date in 1954. Although the total tonnage had increased it only represented 34 per cent of the world total as against 37 per cent in the previous year, since the tonnage building abroad increased by 698,000 tons to a total of 4,139,000 tons gross. According to the returns it was disappointing to note that the annual production rate fell from 1,503,000 tons to 1,341,000 tons and it is hoped that the results of the fourth quarter of the year will raise the rate to a figure comparable with that of the previous year. The tonnage commenced increased by 65,000 tons to 1,407,000 tons gross, while launchings, at 1,355,000 tons, were lower by 71,000 tons and these trends were reflected in the returns for other countries.

German shipbuilding continued the expansion noted in previous years and the industry's order book reached a total of about 1,900,000 tons, although the tonnage under construction remained substantially the same and at 11·4 per cent of the world total made that country our principal competitor. The Netherlands, Japan, France and Italy, in that order, followed, and Japan, by reason of receiving large numbers of export orders, reversed the recession noted in 1954 and stepped into the position previously occupied by Sweden. Ships being built in Great Britain for registration abroad amounted to 35 per cent of the total compared with the figure of 44 per cent for the rest of the world. However, percentages varied widely between different countries with Japan at 94 per cent by far the largest exporter of tonnage, the respective amounts for Sweden, Germany and France being 60, 53 and 44 per cent. These figures show the comparative dependence of these countries on the export market and by the same token a measure of their competitive strength.

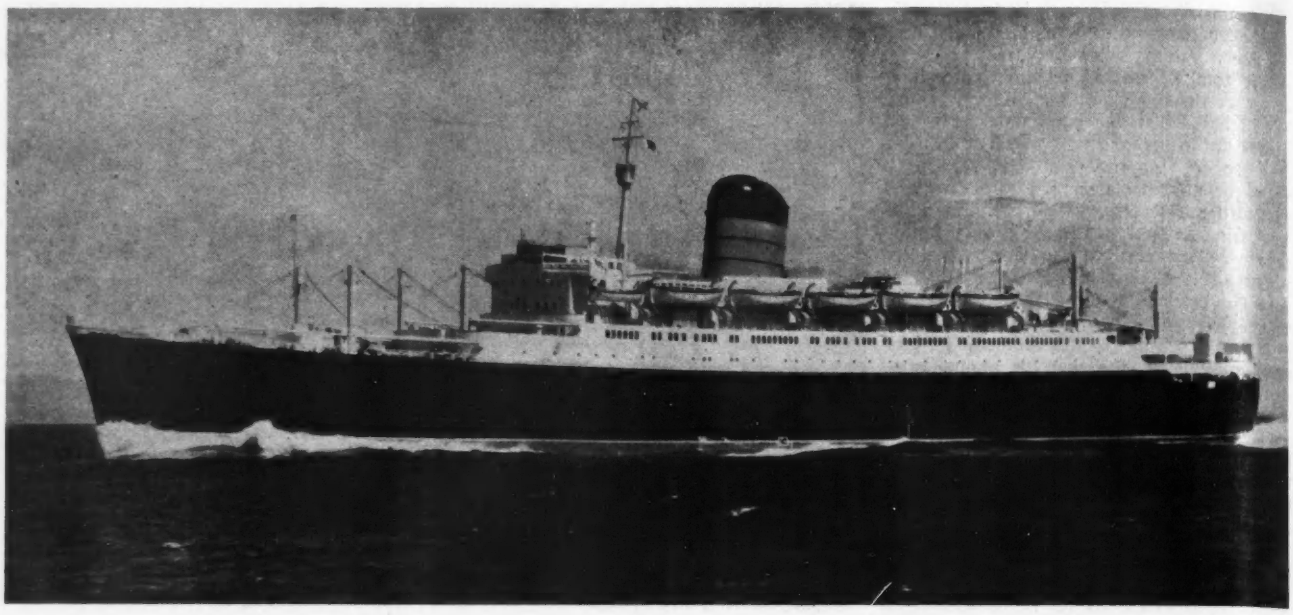


M.V. "Triaster," built by Harland and Wolff, Ltd., at Govan, for the British Phosphate Commissioners, has a length between perpendiculars of 485ft, a breadth moulded of 67ft 6in, a depth moulded to shelter deck of 42ft, and carries a deadweight of about 12,000 tons. Forty-eight passengers are in single, double and three-berth staterooms, and the ship is propelled by a two-stroke, single-acting, opposed-piston oil engine having six cylinders of 750mm diameter by 2000mm combined stroke and developing 6500 b.h.p. at 110 r.p.m.

Oil tanker construction continued to represent the greater proportion of the ships under construction, but was lower at 46 per cent, of which 39 per cent was for foreign account. In the other leading shipbuilding countries, namely, Germany, the Netherlands, Japan, France and Italy, oil tankers represented, respectively, 20, 49, 58, 66 and 36 per cent of the total, while the amount for export was 83, 26, 96, 43 and 28 per cent respectively. Of the 2,147,000 tons gross under construction in Great Britain the following represents an approximation of how the tonnage was divided among the various classes of ships: passenger and passenger-cargo liners 9·3 per cent; cargo liners 33·1 per cent; cargo tramps 7·3 per cent; oil tankers 46·2 per cent; the remaining 4·1 per cent being colliers, coasters and other small craft. These returns show that there was a small increase in passenger and passenger-cargo liners, a large increase in cargo liners, a further small drop in cargo tramps and a large fall in oil tankers. The addition of ships preparing to those under construction raised the total to 3,473,000 tons gross and the corresponding group percentages were amended as follows: 7·7, 34·9, 8·7, 44·9 and 3·8. It must be remembered that these divisions apply to the end of September and no doubt will need some revision, since the



The Shaw Savill Liner "Southern Cross," which is a one-class ship designed to carry 1160 tourist passengers in the company's round-the-world service to Australia, New Zealand and South Africa, was built and engined at Belfast by Harland and Wolff, Ltd. The ship has a length between perpendiculars of 560ft, a breadth moulded of 78ft, a depth moulded to main deck of 45ft 3in, a load draught of 25ft 1in, and a gross tonnage of 20,200 tons. Six 600kW diesel-driven generators provide the electrical power and a service speed of 20 knots is maintained by two sets of double-reduction geared turbines. The machinery, installed right aft, develops 20,000 s.h.p. and is supplied with steam at 500 lb per square inch and 800 deg. Fah. by three Yarrow boilers



The liner "Ivernia" is the second ship, of a group of four, completed by John Brown and Co. (Clydebank) Ltd., for the Canadian service of the Cunard Steam Ship Company, Ltd., and the principal dimensions are: length overall, 608ft 3in; breadth moulded, 80ft; depth moulded to "A" deck, 46ft 3in; load draught, 28ft; cargo capacity, 300,000 cubic feet, and gross tonnage about 22,000. There is accommodation for 110 first-class and 833 tourist-class passengers, and four 750kW turbine-driven generators meet the demands for electrical power. Two sets of double-reduction geared turbines are installed and supplied with steam at 550 lb per square inch and 800 deg. Fah. by four Yarrow design end-fired water-tube boilers

orders for the last quarter of the year included a large proportion of the oil tanker contracts.

The question of the amount of tonnage completed has been mentioned previously. It was essential that a total of 1,500,000 tons should be achieved or even exceeded if full advantage was to be gained from the reconstruction which has been carried out in most shipyards. Although steel production increased, supplies were not able to meet all demands; however, some easement may have resulted from the credit restrictions designed to curb some development schemes and so release steel for the more important industries. With no large warship programmes to divert both labour and material, it should be possible to raise production; another factor helping towards this would be the economic use and exploitation of new facilities, new techniques and increased mechanisation. This depends a great deal upon imaginative planning by the management and to a greater extent upon labour looking forward instead of backward, ceasing to think of present problems in terms coloured by the lean years, and abolishing restrictive practices, many of which are outmoded and which help to increase costs, retard construction and adversely affect our competitive strength. With those employed in the industry, numbering about 125,000, exclusive of the naval dockyards and including both new and repair work, it is evident that there is no labour reserve to call upon to increase production. Actually the reverse applies: there is a shortage of skilled labour in a number of trades so that increased production largely depends upon a more economic and flexible use of labour; that is, no rigid lines of demarcation, a higher degree of mechanisation and planning to ensure the maximum use of machinery.

Based on the volume of orders and the rate of completion there is every reason to be optimistic for the future of British shipbuilding, but this optimism should not obscure the need to increase production. Neither should the bright outlook induce any false feeling of complacency, for full berths provide the industry with the opportunity to put its house in order and to sharpen its competitive ability against the time when more orders are required.

It has been interesting to note the change in the powering of the merchant navy; coal as fuel was used by only 11 per cent of the ships as against 45 per cent in 1939, the remainder in each instance burning oil, while the fleet was divided between steamships and motorships in the proportion of sixty-seven to thirty-three, the comparative figures for 1939 being seventy-five to twenty-five.

The ship repairing section of the industry, which employs about 40,000 men, enjoyed a successful year and it was considered that 1956 held similar prospects of steady employment. During the year a considerable volume of survey, maintenance and conversion work, valued at about £65 million, was carried out despite strong competition from continental repairers. The industry used a relatively small quantity of steel compared with new construction; nevertheless, that amount was vital if there was to be no delay in completing contracts. An important question, especially with the appearance of the large deadweight tanker, was that of the availability of dry docks of sufficient size.

Shipowners continued to underline the fact that British shipping had to contend with fierce competition which in many instances was weighted in favour of the ships of particular nations by means of various and devious financial adjustments, in short, subsidies. These were aided by a number of practices and regulations, which in effect were blatant flag discrimination. Such contraints adversely affected the free market for world shipping and, despite our native skill in controlling shipping, had and were having a harmful effect on the British merchant marine. Each year our share of the world tonnage continued to shrink and the latest return available indicated that it was about 19 per cent compared with 26 per cent in 1939. Sea transport contributed at least £220 million to the balance of payments last year.

The question of fixed prices remained well to the fore, but no formula to attain this ideal was put forward and with delivery dates at least three years ahead the problem appears insoluble. That shipbuilders are reluctant to subscribe to a fixed price system is not surprising when it is considered that they are essentially assemblers of an end product so that they not only have to meet an annual increase in wages in their own industry, but have to absorb increased costs passed on by a wide variety of industries, with the biggest factor influencing costs being the nationalised industries. From the spate of orders placed during the year, it appears that shipowners have tacitly accepted the sliding scale basis of costing in spite of their reluctance to sign a blank cheque. No doubt higher freight rates, at an index number of about 150 taking 100 for 1952 as a basis, have some influence, but other factors, such as the ever-present need for tonnage replacement, affected the issue. With over 50 per cent of the liner fleet and over 60 per cent of our tramps more than ten years old, and ships representing more than 2,000,000 tons more than twenty-five years old, there was every indication that orders had to be forthcoming. Indeed, to maintain the merchant fleet at its present size requires an average of about 800,000 tons to be ordered each year.

(To be continued)

Book of Reference

Year Book of the Heating and Ventilating Industry. London: Technitrade Journals, Ltd., 8, Southampton Row, W.C.1. Price 7s. 6d.—This, the ninth. edition of this valuable reference book for architects, consulting engineers and others dealing with heating and ventilating contractors, has been revised and brought up to date. The special articles this year include the following:—"Studies in Fuel Consumption," by A. C. Pallot; "Heating and Ventilating on the Farm," by C. N. Davies; "Some Notes on the Correct Selection and Application of Unit Heaters," by E. B. T. Turner, and "Panel Heating," by H. H. Bruce. Particular attention is drawn to the new "Form of Direct Contract" prepared by the Federation of Specialists and Sub-Contractors for use where a specialist firm undertakes work otherwise than under sub-contract. As in previous years, the book has been compiled in collaboration with the Association of Heating, Ventilating and Domestic Engineering Employers and provides much useful technical as well as trade information.

Electrical Engineering in 1955

No. I

IN an article written for THE ENGINEER Centenary Number published last Wednesday, Sir Claude Gibb recalled that the electrical industry is rather less than a hundred years old. In 1856 electricity was little more than a scientific curiosity with interesting possibilities. Many of these possibilities are only now coming to be realised and most of them are the fruits of progress made with in the last fifty years or so. Some of these developments, such as the growth of world-wide telecommunication links and television, the applications of electronics to industry and the beginnings of automation are even more recent.

To-day electricity is a commonplace commodity in the factory, the office and the home and to an increasing extent on the farm. It is generated in power stations, many of which have outputs of more than 1000MW—that is, a thousand times greater than the outputs of stations which were considered large at the beginning of the present century. Again, as Sir Claude pointed out in his article, the first turbo-generator, which was built in 1884, required the combustion of 22 lb of coal to produce a unit of electricity. In a typical installation of 1900 the consumption was reduced to about 3 lb of coal for a unit of electricity. To-day, in a modern plant, the corresponding figure is appreciably less than 1 lb of coal, and that of inferior quality.

These figures illustrate the improvements made over a period of seventy years, but they also constitute an example of the law of diminishing returns, showing as they do that, if thermal efficiency be used as a criterion of technical progress, then it requires increasing efforts to win ever smaller gains. Such is the course of many engineering developments ; if we exclude the impact of occasional revolutionary discoveries, progress becomes a slow march in which it is usually hard to assess the value of each individual step. It is with this thought that we approach the task of trying to record British developments in electrical engineering year by year. Here our intention is merely to recall some of the events and achievements of 1955 that typify the general trends of progress.

Electricity Supply

In the seven years since vesting day, April 1, 1948, the number of consumers supplied by the Central Electricity Authority has increased by 27 per cent and the annual sales of electricity to these consumers has increased by 76 per cent. The increase in the year ended March 31, 1955, was 11·8 per cent, which is more than the average for the seven-year period, and indicates an upward trend in consumption.

To match these demands the installation of new generating plant has been speeded up considerably in recent years, as can be seen from the accompanying figures :—

Year ended March 31st	New generating plant, MW sent out
1949	423
1950	831
1951	918
1952	1192
1953	1423
1954	1419
1955	1539

Despite the increased rate of installation of new plant, the total amount installed by the end of 1954 fell short of that originally planned to such an extent that a total of 996MW for the programmes for 1948–54 had not been commissioned. The deficiency, however, was 460MW less than it was at the end of 1953, when the total outstanding from the 1948–53 programmes was 1456MW. This figure, it will be seen, is roughly equivalent to the whole of the new plant installed in each of the years 1953–55.

In fact, there is still insufficient generating capacity to meet the maximum potential demand, that is, the demand actually supplied plus the estimated amount of load reduction caused by low frequency, reduction of voltage or disconnection of supply. In 1954–55, for example, the estimated shortage of generating capacity at the time of maximum potential demand (on Thursday, January 20, 1955) was about 950MW sent out. This was actually higher than the corresponding estimated shortage for the previous winter of about 870MW, on February 2, 1954. Allowing for the effect of weather the position was even less favourable, and it was estimated that the plant shortage would have been about 2200MW if there had been severely cold weather in mid-December either in 1953 or 1954.

Generating Plant Programmes

The main items of steam generating plant commissioned in England and Wales up to December 12, 1955, are given in Table I overleaf. Seven new stations are indicated. Brief descriptions of three of them, Marchwood, Portishead " B " and Stella North have appeared in previous issues of THE ENGINEER.* Illustrations of Goldington, Portishead " B " and Stella North are reproduced in Plates 2 and 3 between pages 8 and 9 of the present issue.

* September 17, 1954, page 391 ; July 9, 1954, page 60 and July 10, 1953, page 51.

Of these new stations Meaford " B," which is near Stoke-on-Trent, is interesting because of the steam conditions, 1500 lb per square inch and 1050 deg. Fah. at the turbine stop valve. The station is being completely engineered by the headquarters staff of the Central Electricity Authority. Ultimately it will have an installed capacity of 240MW, consisting of four B.T.H. 60MW hydrogen-cooled turbo-alternators with four pulverised fuel-fired 515 klb per hour boilers. Coal will be brought by rail from the nearby North Staffordshire coalfields. There will be three cooling towers, each with a capacity of 3,150,000 gallons per hour. The station building foundations are piled.

It will be seen from Table I that of the twenty-eight newly-commissioned generating sets, nineteen have been installed in existing stations. A general view of the turbine hall of one of these stations, Ince, is reproduced herewith, showing the third set in the background. The two remaining illustrations show hydro-electric generating plant under construction in the makers' works and they may be taken as being typical of contracts in hand by British manufacturers for service overseas ; reference to other hydro-electric schemes will be found in the article on " Civil Engineering in 1955," elsewhere in this issue.

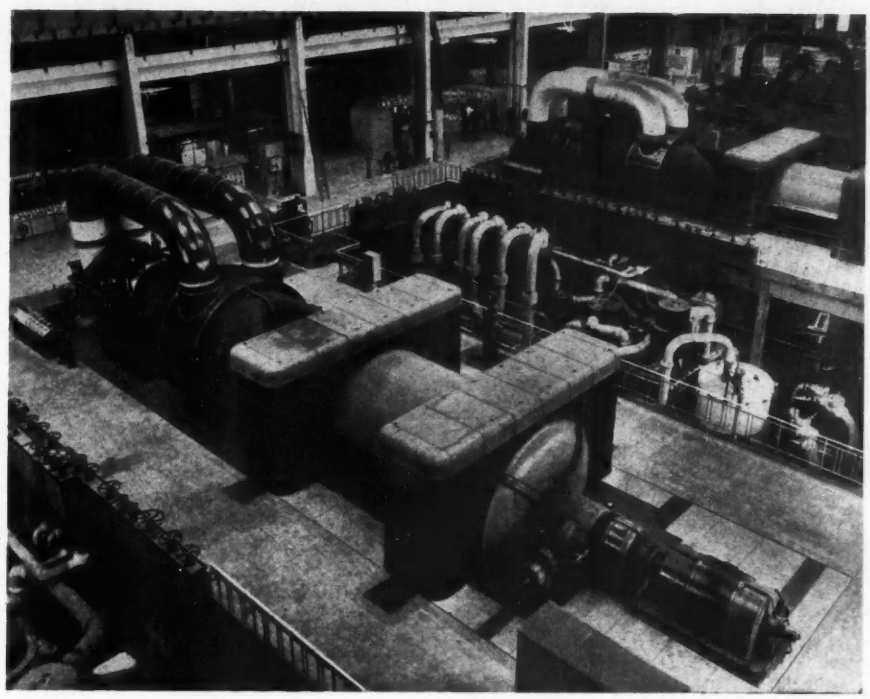


Fig. 1—One of three G.E.C. 60MW hydrogen-cooled turbo-alternators which have been commissioned at Ince power station. Steam is taken at 900 lb per square inch and 900 deg. Fah. from four " semi-outdoor " International Combustion boilers, each with an evaporative capacity of 550 klb per hour

Future Programmes and Developments

During the year under review the generating plant programme for 1960 was approved. It covers Great Britain,† excluding the North of Scotland district, and provides for one set of 100MW, seven of 120MW and two of 200MW besides fourteen " standard " 60MW sets. The reason for the numerical preponderance of 60MW sets is that they are to be installed in stations that were already started in earlier programmes.

† As from April 1, 1955, the title of the British Electricity Authority was changed to Central Electricity Authority. At the same time, the organisation was reconstituted in such a way that the C.E.A.'s undertaking in Scotland and the undertakings of the two Scottish Area Boards became vested in a new public authority called the South of Scotland Electricity Board. Accordingly, the C.E.A. Generating Divisions were reduced in number from thirteen to eleven and the Area Boards from fourteen to twelve.

Site work was started in 1955 on the building of the new station at High Marnham (Notts) on the River Trent. It will be the largest power station yet projected in Great Britain and the authorisation by the Minister of Fuel and Power covers the installation of five 200MW turbo-alternators and five unit boilers. The stop-valve steam conditions will be 2350 lb per square inch at 1050 deg. Fah. with reheat to 1000 deg. Fah. The initial contract for the turbo-alternators has been placed with the English Electric Company, Ltd. The turbine will be a three-cylinder, tandem-compound, 3000 r.p.m. machine with triple exhausts. Feed heating will be effected in six stages, the final feed temperature being 460 deg. Fah. and the reheat pressure 490 lb per square inch absolute at the turbine exhaust. By adopting internal cooling with hydrogen for stator and rotor conductors the weight of the alternator will be kept within road transport limits. The boilers will be of twin furnace design with assisted circulation. Design studies on the High Marnham station point to the conclusion that building costs will be reduced by arranging the turbo-alternators in tandem along the turbine room. The first set is scheduled to be in operation in 1959.

On the assumption that an average annual thermal efficiency of about 33 per cent may be anticipated for this station, some interesting comparisons may be made with the data given in Table II, abstracted from the seventh annual report of the Authority. The true significance of these figures lies in the fact that the twenty stations with an average thermal efficiency of 28·74 per cent generate only slightly over one-quarter of the total quantity of electricity. The bulk, nearly three-quarters of the total, is produced by stations having an average thermal efficiency of only 22·74 per cent. If this average could be raised to that of the top twenty stations, 28·74 per cent, the annual saving in coal would be more than 7,000,000 tons.

TABLE I—*New Steam Plant Commissioned by the Central Electricity Authority in England and Wales During* 1955 (*up to December* 12*th*)

Division	Name of station	Turbo-alternators		Boilers	
		No.	MW	No.	klb/hr
London	Acton Lane "B"	1	30	1	240
	Battersea "B"	—	—	1	425
	Brunswick Wharf	1	60	—	—
	Hackney "B"	1	30	1	300
South Eastern	Brighton "B"	1	52·5	2	320
	Littlebrook "C"	—	—	1	360
Southern	Cowes	2	12·5	2	135
	Marchwood*	1	60	1	550
South Western	Portishead "B"*	1	60	2	300
Eastern	Brimsdown "B"	1	60	2	340
	Goldington*	2	30	2	300
East Midlands	Drakelow "A"	2	60	3	515
	Staythorpe "A"	—	—	1	240
Midlands	Meaford "B"*	1	60	1	515
South Wales	Carmarthen Bay	2	60	4	240
	Uskmouth "A"	1	60	2	240
Yorkshire	Doncaster "B"	—	—	2	180
	Huddersfield	1	30	1	180
	Keadby	1	60	1	550
	Skelton Grange "A"	—	—	1	550
	Wakefield*	—	—	1	550
North Eastern	Stella North*	2	60	2	550
	Stella South	1	60	2	550
North West, Merseyside and North Wales	Blackburn	—	—	1	150
	Carrington	—	—	1	360
	Clarence Dock	—	—	1	350
	Connah's Quay	2	30	2	300
	Fleetwood*	2	30	2	300
	Huncoat	1	30	—	—
	Ince	1	60	2	550
	Total	28	1277	45	15,955

* Indicates new stations.

TABLE II—*British Stations with Highest Thermal Efficiencies in Year Ended March* 31, 1955

Power station	Stop valve steam pressure, lb/sq in	Stop valve steam temperature, deg. Fah.	Maximum output capacity, kW s.o.	Electricity sent out, million kWh	Average load, % of maximum output capacity	Calorific value of fuel, B.Th.U./lb	Fuel burnt, lb per unit s.o.	Thermal efficiency
Portobello H.P. (Edinburgh)	1,350	950	112,000	631·037	91	10,388	1·046	31·42
Stourport "B," L.P.	1,250	950	56,000	462·310	94	9,855	1·123	30·83
Littlebrook "B" (Dartford)	1,235	825*	113,000	783·333	79	11,432	0·979	30·49
Dunston "B II" (Newcastle upon Tyne)	600	850†	96,000	725·263	86	11,193	1·025	29·74
Bromborough	900	900	197,000	1,354·139	82	11,049	1·059	29·15
North Tees "C" (Middlesbrough)	900	925	224,000	1,171·731	60	10,171	1·155	29·05
Totals or averages for: "Best" twenty stations, 1954–55			3,437,000	18,858·414	70	10,865	1·093	28·74
"Best" twenty stations, 1953–54			2,830,000	14,635·977	66	10,733	1·117	28·45
Totals or averages for: Other steam stations, 1954–55			14,748,000	50,002·183	40	10,737	1·418	22·41
Other steam stations, 1953–54			13,844,000	46,971·790	40	10,794	1·425	22·17
Totals or averages for: All steam stations, 1954–55			18,185,000	68,860·597	45	10,766	1·329	23·85
All steam stations, 1953–54			16,674,000	61,607·767	44	10,782	1·352	23·40

* Steam reheated to 825 deg. Fah. at 354 lb per square inch. † Steam reheated to 850 deg. Fah. at 135 lb per square inch.

Fuel Supplies and Nuclear Power

Shortage of coal is one of the major problems facing the electricity supply industry. There is a gap between the Central Electricity Authority's estimated future requirements for coal and the National Coal Board's estimates of the possibility of supplying them—a gap which will become increasingly serious from 1960 onwards. Clearly the most promising long-term solution of this problem is to generate electricity from atomic energy. But, although the provisional ten-year programme‡ for nuclear power generation envisages the building and commissioning of twelve nuclear power stations by 1965 (with a total generating capacity of 1500MW to 2000MW) the resultant savings in coal will only partly offset the threatened coal shortage. A succinct analysis of the prospects of fuel supplies for power stations was given in a paper read by Mr. V. A. Pask at the recent inaugural meeting of the British Nuclear Energy Conference. Briefly, Mr. Pask showed that even if it had been possible to double the ten-year programme for nuclear power stations there would still be not enough fuel for the coal-burning stations required in 1965 to 1975.

Discussions between the Ministry of Fuel and Power and the Central Electricity Authority showed that the short-term remedy for the lack of home-produced coal was to import oil rather than coal. The Authority has therefore been studying the possibility of using oil on a much larger scale than had been previously contemplated. One outcome of these studies has been the negotiation of an agreement whereby Marchwood power station on Southampton Water will take heavy fuel oil from Fawley refinery at a price calculated to yield generation costs equal to those given by coal. Accordingly, the design of the station has been changed to allow for firing by coal or oil, and oil will be the normal fuel. The first set was commissioned last year and, when the station is complete, the annual oil consumption will be 430,000 tons instead of 600,000 tons of coal.

To provide for oil burning on a wider scale two agreements for the supply of oil were completed during the year under review. The first agreement concerns seven stations, namely, Barking, Brunswick Wharf, Littlebrook and Tilbury on the Thames, and Poole, Portishead and Plymouth. The fuel will be delivered to most of these stations at a cost not exceeding that of the equivalent quantity of coal. By 1960 the stations are expected to be burning between 2,750,000 and 3,000,000 tons of oil annually, saving over 4,000,000 tons of coal. The second agreement relates to another seven stations, namely, Belvedere, Bromborough, Carrington, Cliff Quay, Ince and South Denes, and another station (projected) on the Thames. The oil supplies will eventually be equivalent to nearly 5,000,000 tons of coal annually.

Last October the Central Electricity Authority announced that sites had been chosen on which it was proposed to build the Authority's first two nuclear power stations. One site is at Bradwell, Essex, at the mouth of the River Blackwater, and the other is at Berkeley, Gloucestershire, on the Severn Estuary. Subject to approval of these sites by the local planning authorities and the Minister of Fuel and Power, the intention is that building work should be started in 1957 and that both stations should be generating electricity commercially in 1960–61. Both stations will, like Calder Hall, use gas-cooled graphite-moderated reactors to generate heat, with heat exchangers to produce steam for turbo-alternators. But, unlike Calder Hall, the main product will be electricity, not plutonium, and the generating capacity of each station is likely to be of the order of 200MW.

The design of later stations in the ten-year nuclear power programme will depend on the progress of the Atomic Energy

‡ White Paper (Cmd. 9839), February, 1955.

Authority's experimental reactor programme and on the experience gained from the building and operating of the earlier stations. The C.E.A. believes that, if all goes well, it may be possible to accelerate the construction of nuclear stations to match the total requirements for new generating capacity.

In the long run, then, the development of nuclear power generation is likely to lead to marked changes in the present balance of fuel supplies and consumption. Equally important changes may well be envisaged in the siting of nuclear power stations and in the growth of the associated main transmission and interconnection system. Some of these points were discussed in Mr. Pask's paper, to which we have already made reference.

For example, sites for nuclear power stations should be capable of carrying loads of about 3 tons per square foot, to support the heavy weight of existing designs of reactor and shielding. In addition the cooling requirements are generally larger than for conventional stations of equivalent capacity. On the other hand, the problems of transporting bulk fuel and ash disappear. Rail access is unimportant and, since fuel costs are almost independent of siting, it becomes sound economics to build nuclear power stations in places where conventional fuels are expensive and as near as possible to the main load centres.

The new pattern of power station siting may be expected to influence later developments in the 275kV Supergrid. As planned for 1960, the 275kV system will consist of about 2500 circuit miles connecting the main generating and load centres, mainly for pooling of spare generating plant. But up to 1960 part of the base load in southern England will be generated in the Midlands and transmitted south, three of the six 275kV circuits being intended for this purpose.

Between 1960 and 1970, however, more nuclear power stations are likely to be sited on estuaries and the coast and to take over base load operation, a high load factor being desirable for economic reasons. Eventually the transmission of electricity from the coal producing areas of the Midlands will become uneconomic, but it is anticipated that by about 1970 all the six 275kV lines will be required for interconnection on the basis of pooling of spare generating plant. The need to operate nuclear power stations at high load factor gives fresh emphasis to the virtues of pumped storage. Furthermore, the prospect that it will ultimately be cheaper to produce electricity from nuclear power than from coal suggests that future coal burning stations must be designed for two shift working. This requirement is, therefore, being specified for the future "standard" sets of 120MW output (with steam conditions of 1500 lb per square inch, 1000 deg. Fah., reheat to 1000 deg. Fah.) and of 200MW output (with steam conditions of 2350 lb per square inch, 1050 deg. Fah., reheat to 1000 deg. Fah.).

Reverting to a consideration of the present transmission system, we find that sections of the 275kV Supergrid, consisting of about 140 miles of double-circuit line between Stella, near Newcastle upon Tyne, Carlisle, and Clyde's Mill, near Glasgow, were completed in 1955; they were taken into service at 132kV temporarily, pending commissioning of the 275kV substations in 1957. Similarly, the 25 miles of line between Monk Fryston, near Ferrybridge, and Keadby, near Scunthorpe, were also energised at 132kV by temporarily connecting to one circuit of the Stella-West Melton 275kV line which is operating at present at 132kV. Installation of other sections of the Supergrid went ahead rapidly during 1955 and the following sections were due to be in operation before the end of the year at their designed voltage: the lines between Staythorpe, near Newark, and Drakelow, near Burton-on-Trent; Drakelow and Carrington, near Manchester; Staythorpe and Elstree and Elstree and Iver. A general view of the switchgear at Drakelow substation was reproduced last week.

As stated in the Authority's seventh annual report, schemes for the future connection of 1900MW of new generating plant to the grid system were approved. They included initial connections for the large new power stations at Belvedere, near Erith, Kincardine and Willington, near Derby, and for a smaller station at Rogerstone, South Wales. More than a quarter of this new capacity, consisting of three 100MW alternators at Castle Donington, near Derby, and two at Willington will be connected direct to the 275kV Supergrid. They will constitute the first installations for switching generator sets at 275kV as part of the scheme for transmitting power in bulk southwards from power stations now being built near the Midlands coal fields.

(To be continued)

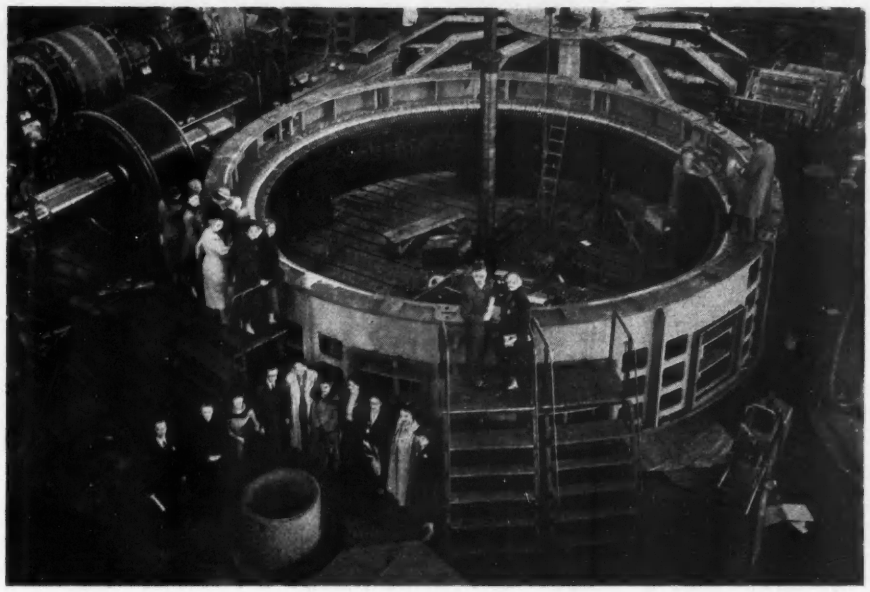


Fig. 3—The stator of a 66,667kVA, 150 r.p.m., vertical waterwheel alternator for Eildon power station of the State Electricity Commission, Victoria, Australia. Two such machines are being manufactured by the British Thomson-Houston Company, Ltd., Rugby

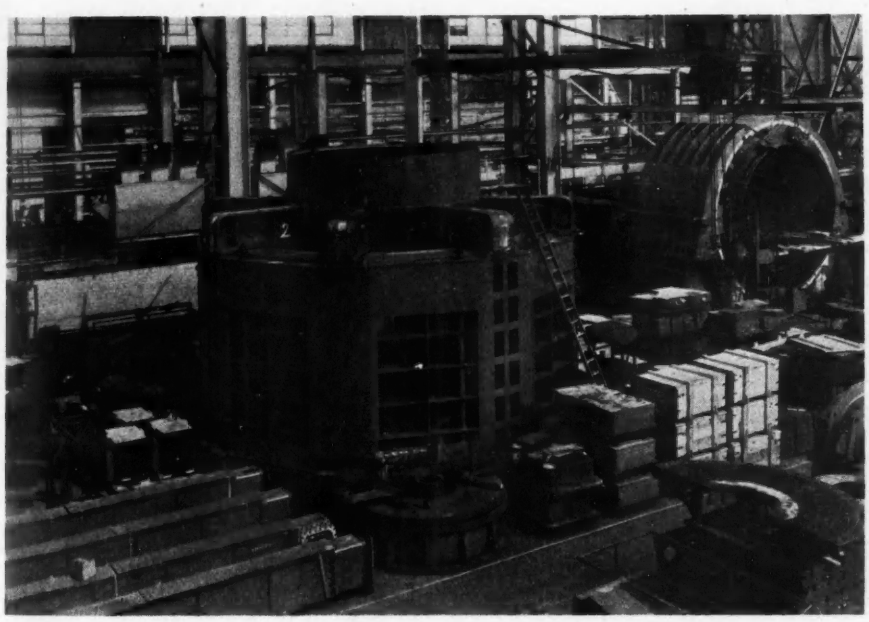


Fig. 2—Four 138MW vertical waterwheel alternators are being built by Metropolitan-Vickers Electrical Company, Ltd., for the La Casse Development on the Bersinis River, which supplies power mainly to Quebec and Montreal. The first alternator is seen here in the maker's works

FACTORY EQUIPMENT EXHIBITION, 1956.—It is announced that the fourth Factory Equipment Exhibition will be held at Earl's Court from April 9 to 14, 1956. The exhibits will cover factory construction, equipment and maintenance; goods handling, storage and packing; engineering products, equipment and services for welfare and safety, and drawing and works office equipment and supplies. During the course of the exhibition the British Productivity Council will hold a three-day conference.

Civil Engineering in 1955

No. I

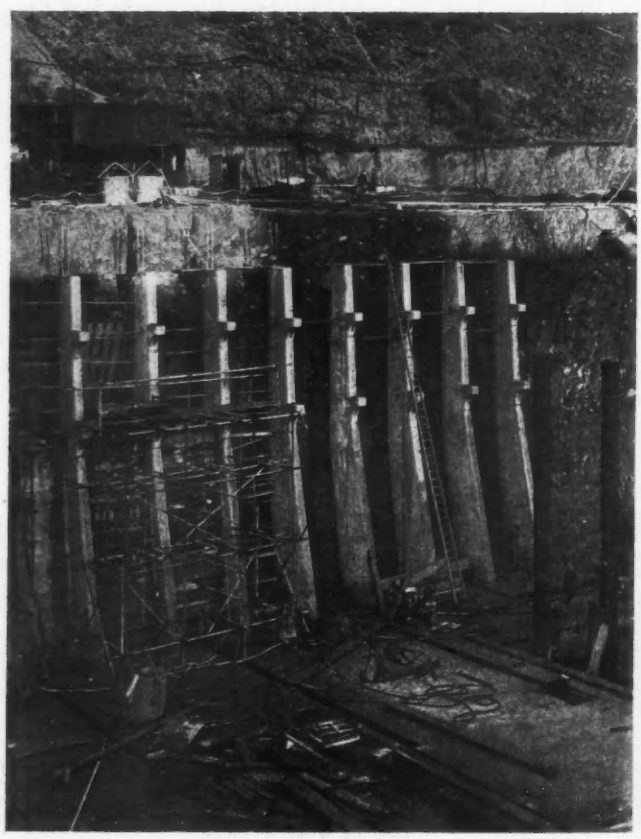
LOOKING back over the events and achievements of 1955 in the world of civil engineering, our first impression was that the year passed rather quietly. A closer study, however, indicated considerable progress and as far as can be judged the activity of the industry was greater than in 1954, thus continuing the growth in output which has been sustained since the end of the war. In our annual review of 1954, published last January, it was pointed out that official statistics relate to building and civil engineering taken together, and no figures for purely civil engineering work are compiled. For the two together, however, the labour force employed increased to over 1,000,000 during the year ; the combined output, which stood at £1849 million in 1954, was respectively, £416 million, £456 million and £484 million during the first three quarterly periods of 1955. The same post-war trend, of gradually increasing activity as the overall economic circumstances permitted, was thus still apparent in 1955 ; it is, however, too early yet to see any effect of the autumn budget, which by restricting capital expenditure and increasing interest rates may retard some of the new civil engineering projects.

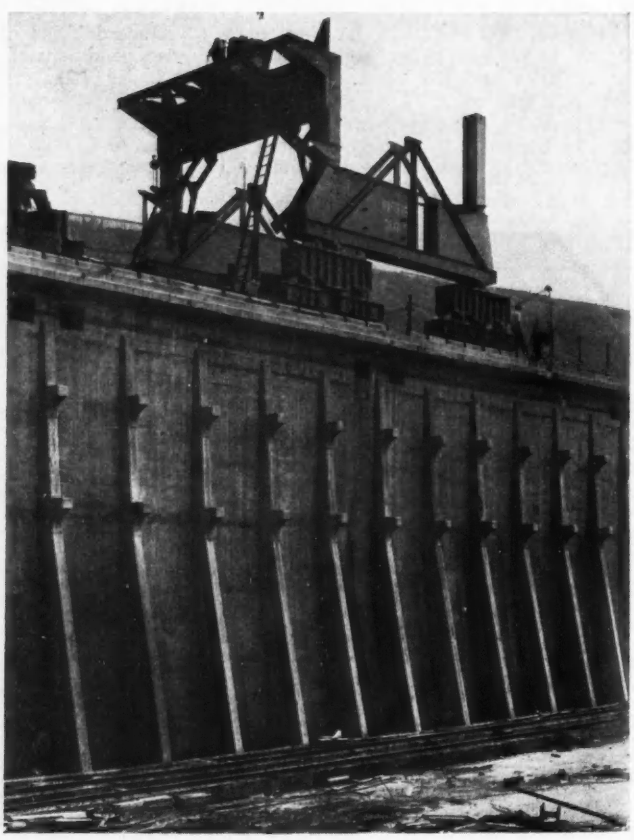
All this activity in 1955 was reflected in the opening of several large schemes during the year, generally well-known ones which have been under construction for a number of years. Pride of place goes to the Haweswater aqueduct (Plate 9), probably the largest civil engineering scheme to be completed in Great Britain since the war. The Neath by-pass bridge and viaduct (Plate 13) the only major post-war bridge, was also opened. The large installation of primary sedimentation tanks at the London County Council's Northern Outfall was inaugurated last July, as was the Usk Scheme for the water supply of Swansea last August. An idea of the size of these schemes is given by their overall costs. The Haweswater aqueduct—the second stage of a long-term scheme—will cost about £15,000,000 to complete, but some works (valued at about £4,000,000) are still in progress. The aqueduct was completed with one line of pipes at the time of its inauguration, and the works now being done are due for completion in 1958. The cost of the Usk Scheme was about £3,000,000 and about £2,000,000 each was spent on the completed L.C.C. works at the Northern Outfall and the Neath bridge. These four major works were all described in detail during the year and so we shall not refer to them again in this review, although they do represent the major achievements of the year in actual construction. One other large scheme (of about £1,000,000 cost) inaugurated during the year was the Weir Wood water supply in Sussex, for Crawley New Town and neighbouring areas. The first stage in the construction of the central terminal area of London Airport was also completed. This has involved building and civil engineering works costing about £4,000,000.

Contemporary civil engineering activity is well illustrated by the *Tabular Summary of Civil Engineering Contracts* published with THE ENGINEER of December 23rd last, in which the major works in progress are listed. An appreciable proportion of these works are being carried out overseas, and the overseas activities of British consulting engineers seem to have shown signs of increasing during the year.

Apart from those major works completed, it is also of interest to note one or two schemes for the future. Here, again, one scheme is outstanding in scope and interest—the high dam project at Aswan in Egypt. The appointment of Sir Alexander Gibb and Partners as consultants for the project was announced last November. Egypt's ten-year development programme is centred on this project, which envisages a large rockfill dam 3½ miles upstream from the existing Aswan dam, to give a storage reservoir of 105 million acre-feet capacity. Irrigation and reclamation works are envisaged as part of the scheme, as well as the annual generation of over 4000 million units of electrical power. The same consulting firm is carrying out, in association with the French consultants for hydro-electric works, Coyne and Bellier, the Kariba scheme in Rhodesia. Some preliminary works for this large 1200MW development were started in 1955. Work was also started on the construction of a £7,000,000 airport scheme in Hong Kong, for which Messrs. Scott and Wilson, Kirkpatrick and Partners are the consulting engineers.

Although the water supply and sewerage schemes started during 1955 at the city of Whitehorse in Canada are very modest by comparison with those just mentioned, they are of particular interest because Canada is a comparatively new sphere of influence for British civil engineers. Several con-





Construction of a dry dock at South Shields. The 10-ton precast concrete ribs are shown in position against the clay face of the excavation on the left. The buttressed wall has been almost completed by in-situ concrete in the right-hand view. The altar planks have still to be fixed, and a dockside crane is being erected

tracting firms have been establishing themselves in Canada, but here we have a British consulting firm, Sandford Fawcett and Partners (Canadian-British Engineering Consultants), active in Canada. A number of new drainage and sewerage schemes in overseas territories were due to be let at the end of the year, including an entirely new main drainage system for the city of Baghdad. This work will cost over £7,000,000 and the consultants are John Taylor and Sons.

Apart from actual constructional works, the year 1955 was rich in new civil engineering literature in the form of papers presented at various congresses and symposia, and during the normal course of Institution meetings, where a high standard was, as customarily, maintained. Some of these meetings were international. There was, for instance, the fifth congress on large dams, held in Paris last May and June, which clearly showed that the rate of technical progress of recent years in the design and construction of large dams is being sustained, and there is still widespread construction of this kind in many countries, which shows signs of increasing and of becoming technically even more accomplished. Some of the recent trends, as exemplified by the Congress, were discussed in THE ENGINEER of June 10th and 17th last. There was also an international congress on prestressing at The Hague, which drew attention to another field in which many countries are making rapid progress—the structural use of concrete and particularly prestressed concrete. Last July, the International Water Supply Association held its third international congress, which was in London.

In British research papers there was a well marked emphasis in 1955, on the value of full-scale tests for structures. The Building Research Station emphasised the value of this approach to structural design at its open days, and we commented on the Station's work and the possibility of more economical design which it offers, at the time. The same tendency was apparent in the conference "on the correlation between calculated and observed stresses and displacements in structures," held at the Institution of Civil Engineers last September. An important paper on the strength of composite steel and concrete stanchions, given by Dr. Faber to a joint meeting of the British Constructional Steelwork Association and the Institution of Structural Engineers last December, again emphasised the same approach, for it was based on tests of full-scale structural members in a 1200-ton testing machine. These developments all point to the increasing use of load factor methods of design based on ultimate loads, and of greater attention to structural interaction between the various constituent elements of a structure, and the consequent increase in overall strength which is derived from it.

DRY DOCK ON TYNESIDE

Although the largest schemes completed during the year must necessarily be reviewed, new methods of construction are of equal importance in giving a balanced account of civil engineering progress. The dry dock described below is not only representative of dock and harbour works generally, but also introduces an unusual method of construction. Following the great increase in the sizes and numbers of ships in the oil tanker fleets of the world since the last war, there has been an ever-growing demand for docking and repair facilities capable of handling these "supertankers." The ship-repairing industry has not been unaware of this need and, within the limitations imposed by the high capital cost which is normally associated with the construction of dry docks, has striven to improve and extend existing repair yards. Attempts have been made to build dry docks more economically than by traditional methods; quite recently, we described a dry dock built with steel-sheet-piled walls, but here another solution has been tried.

The new dry dock is suitable for ships up to 38,000 tons deadweight, and makes an important contribution to Tyneside industry; it is now nearing completion at the South Shields yard of Brigham and Cowan, Ltd. This dock is the largest on the Tyne; it is 715ft long, 95ft wide at the entrance and has 25ft of water over the sill at high water springs, and has been constructed in a little over two years at a cost claimed to be much lower than that of comparable structures built earlier, the saving having considerably enhanced the prospects of the project as an economic unit.

The ground at the dock site is stiff boulder clay, and it was apparent from exploratory borings that in this ground, high exposed faces would probably stand without support for several months. A method of construction for the dock walls was specified to take full advantage of these conditions and has been completely successful, we are informed.

The excavation of the body of the dock proceeded in the open, leaving clay sidewalls standing 40ft high. Against these clay faces precast reinforced concrete cantilever buttresses, weighing 10 tons each, were erected at varying centres. Once in position, panels of dock floor concrete cast round the feet of these ribs, formed a base for the wall structure. Infilling panels of concrete cast-in-situ between buttresses and against the clay, completed the lower part of the walls; at cope level a concrete service duct 5ft by 4ft 3in running round the dock links the heads of the cantilevers and accommodates the dockside services. Altars are provided at three levels; two of these are formed by concrete planks resting on projections of the buttresses and the third occurs at cope level. The accompanying illustrations give a good idea of the work, and a general view of the site is shown on Plate 13.

While this method of wall construction was carried forward throughout the dock, the ground conditions for excavation and floor construction were not at all favourable over at least half the length. Bores showed an extensive water-bearing sand deposit occurring with its upper surface at proposed dock bottom level, the standing water in this sand being at about Ordnance Datum, 25ft above the excavation level. To enable construction to proceed, a row of tube wells was sunk on each side of the dock and this water level pumped down until dry working conditions were obtained in the bottom. As a permanent measure to resist the upward pressure developing after pumping was stopped, the dock floor was pinned to the substrata by steel H-section piles driven 45ft and tied into the 4ft thick floor concrete. These piles each carry a load of 30 tons in tension.

The entrance works have been built in steel-sheet-pile cofferdams. This work has included a compact pumping station built to form part of the dock wall just behind the entrance block. Housed in this structure are two Drysdale 30in electrically driven vertical spindle centrifugal pumps, together capable of emptying the dock in four hours. Siphon discharge pipes for these main pumps do away with the need for valves in the system. Two minor 10in pumps are provided for dock drainage and ballast water supply.

The all-welded steel dock gate, which has been built by Head Wrightson, Ltd., is of the Box or flap type, and is one of the largest of this design to be built. Substantial ancillary works have been, or are being, constructed to complete the development scheme, including a large platers' shop and riverside jetties giving an 800ft berth for fitting out. The consulting engineers are G. Maunsell and Partners and the civil engineering contractor is Marples, Ridgway and Partners, Ltd.

Prototype floating waterworks shown in use at Latifiyah, Iraq

WATER SUPPLY

Three large water supply schemes completed in 1955 have already been referred to, and Plate 9 gives further details of representative work of 1955. We refer on Plate 9 to the unusual expedient adopted by the Colne Valley Water Company of using the Hilfield Park reservoir for the storage of underground supplies. This particular case serves to illustrate the general position that shortage of water may become serious in the

future, a possibility recognised by the Ministry of Housing and Local Government. Last October the Minister welcomed the Central Advisory Water Committee, on the resumption of its work, and the committee subsequently initiated inquiries into the extent of increase in the use of water which is likely to occur, and into the possibility of making a balanced survey of the water resources which are available. No reports have been published yet.

The technical problems facing the water engineer to-day were reviewed at the international congress held last July. The congress was accompanied by an exhibition of plant and equipment for the water supply industry, which is believed to be the first of its kind.

A rather unusual design of purification plant for a river-derived supply was described only last month at the Institution of Water Engineers by Mr. G. Smethurst. The water supply installations at Baghdad were explained in his paper, which included an account of a floating purification plant, at a site where there was no opportunity to build a high-level tank, and where pontoon mounting offered advantages so that the feasibility of carrying the whole plant afloat was investigated. The prototype plant is illustrated herewith. An improved design (see THE ENGINEER, December 16th, 1955) is also to be built.

The unit is virtually a self-contained waterworks. River water is settled, filtered, chlorinated and delivered to the main at about 2400 g.p.h. against a head of 80ft. The cycle of operations is completely automatic; periodical cleaning of the filter is simple, as also is the disposal of sludge, &c., in the settling tanks.

There is a complete absence of filter controls, the flow through the filters being self-regulating by the variation of the water level in the purified water tank. Because the unit floats, it is not affected by varying river levels, provided the river itself has the necessary depth for operation.

The plant is made in corrosion-resistant light alloy. It comprises several units of argon-arc welded construction, made in convenient sizes for transport and bolted together. The ancillary equipment, walkway, handrails, and lifting and towing attachments are mainly in steel, protected against atmospheric corrosion.

The main component vessels of the plant—all fabricated in light alloy—are two rectangular section sedimentation tanks; a cylindrical tank containing a filter bed; a purified water tank, annular in plan, surrounding and integral with the filter bed; and two pneumatic booster tanks. There are eight buoyancy tanks of two patterns, all rectangular in section.

The main ancillary equipment, comprising two water pumps, an alum dosing pump, a chlorine dosing pump, and an air compressor and associated electrical equipment, is carried on a steel platform on top of the unit. This platform is surrounded by a steel handrail.

The mooring arm is detachable, and is provided on site to suit local conditions; the arm used in the trials of the unit was 12ft long. The mooring system employs steel hawsers in tension, with the mooring arm acting as a strut between the floating plant and the river bank. The buoyancy tanks keep the vessel stable under all working conditions, including temporary superimposed loading.

The main structure of the unit is symmetrical. In the centre is the cylindrical filter-bed section, surrounded by the purified water tank occupying the annular space between two cylindrical tanks. At either end of the plant are the two pressurised booster tanks. Between these tanks are flat-sided sedimentation tanks, above which are fixed the four main external buoyancy tanks; inside the sedimentation tanks are four relatively small buoyancy tanks. Over the main structure is a steelway deck, carrying the ancillary equipment.

Trends in Sewage Purification

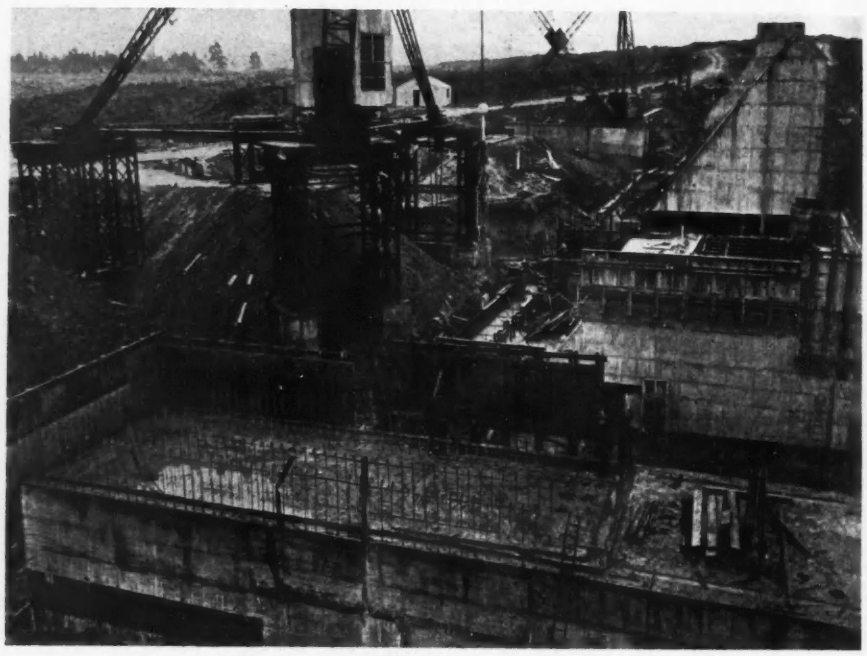
The opening of the Water Pollution Research Laboratory of the D.S.I.R. during 1955 draws attention to the fundamental theory of sewage purification; a brief summary of the present state of knowledge was given by G. Berry and C. R. Deeley in the paper "The Development of Sewage Treatment in the City of Coventry," presented to the Institution of Civil Engineers on November 8th. The following paragraphs have been abstracted from the paper.

"Sewage disposal is far from being an exact science, new processes are continually being investigated, and it may well be that in twenty years' time present methods will appear as obsolete as some of the earlier processes now seem. Future developments are difficult to forecast but one or two obvious trends may be observed from the changes which have already taken place.

"One of these is what one might call an "intensification" of treatment methods—such as the adoption of very high rates of dosing of bacteria beds and the use of mechanical or other aids of flocculation to increase the efficiency of settlement tanks. Another tendency is towards the adoption of various forms of two-stage biological treatment, the earlier objections to such methods being largely removed by developments in gas collection and utilisation practice.

"Increased mechanisation and automatic control are being more generally adopted, partly through availability of cheap power and partly because of the difficulty of obtaining labour for carrying out the rather uncongenial tasks which have to be performed at a sewage-treatment works. There is also an increasing tendency towards the use, by water undertakings, of water taken from streams and rivers. In fact it is not unusual, these days, to find a local authority discharging a purified effluent into a river from which another authority, lower down the river, abstracts water to augment its public water supply. This second authority then subjects the river water to further purification, after which it is re-used for general consumption. One wonders whether this practice may not eventually lead to closer co-operation between sewage-disposal and water authorities.

"It may be that the sewage works of the future will, because of high-intensity methods, occupy a much smaller area than they do at present. It is possible that purification processes may be carried on to a much more advanced stage than is now generally attained, and one can visualise such a plant being almost completely automatic in operation. Before this stage can be reached, however, there is still a great deal to be learned about the complex sewage-purification processes, many of which are still very imperfectly understood."

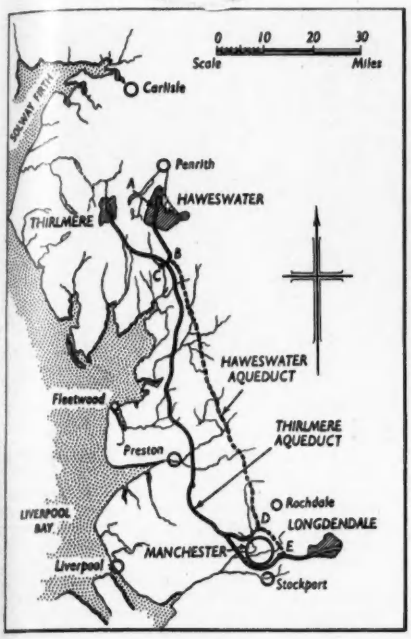


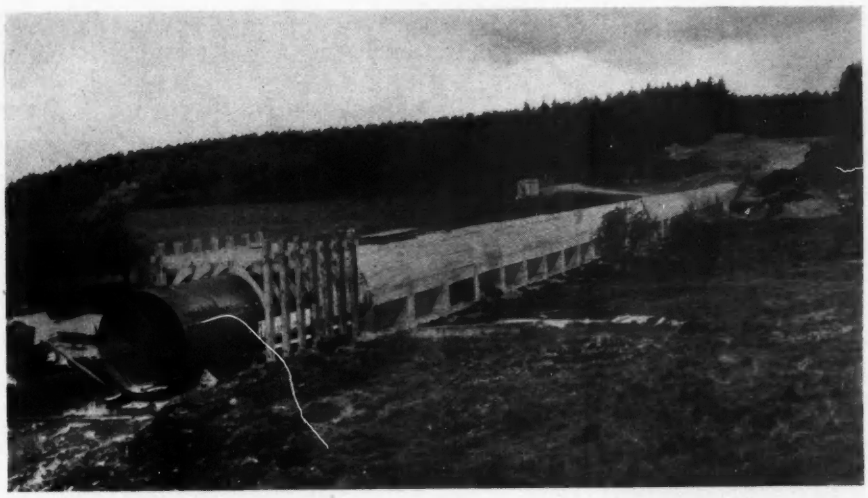
The Lairg dam, which will enlarge Loch Shin in Sutherland, is here shown under construction. The dam will be 38ft high and 1300ft long, and will have a fish-pass and a 3·5MW power station associated with it

Hydro-Electric Works

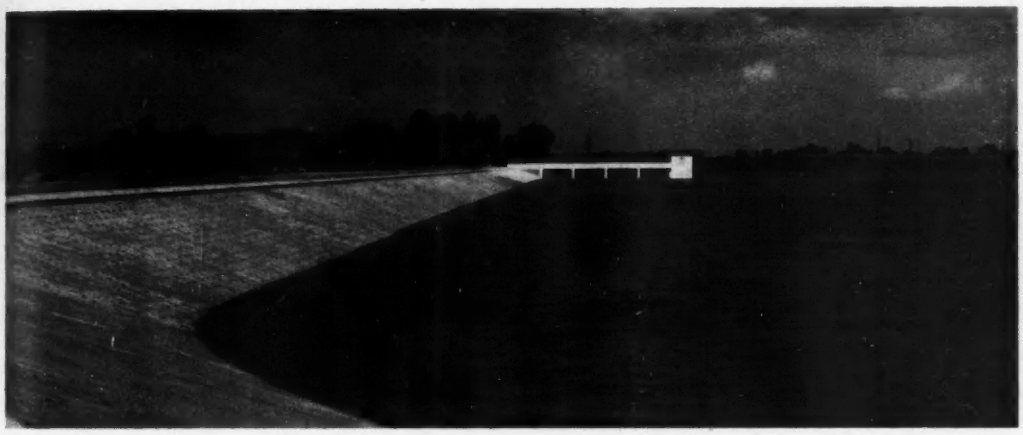
As far as hydro-electric development in Great Britain was concerned, a new interest in 1955 was the imminence of work on two schemes sponsored by the Central Electricity Authority in Wales. Work on aqueduct and power station extensions was in progress at Dolgarrog and Maentwrog, and is due for completion late this year, the civil engineering consultants and contractor being Freeman, Fox and Partners and John Laing and Sons, Ltd., respectively. The much larger schemes to which we refer, however, are a pumped storage scheme with an installed capacity of 300MW, which it is estimated will cost about £11,000,000, at Ffestiniog, in North Wales, and a 49MW hydro-electric development at Rheidol in mid-Wales. The consulting engineers associated with these two schemes are Messrs. Freeman, Fox and Partners,

WATER SUPPLY SCHEMES OF 1955

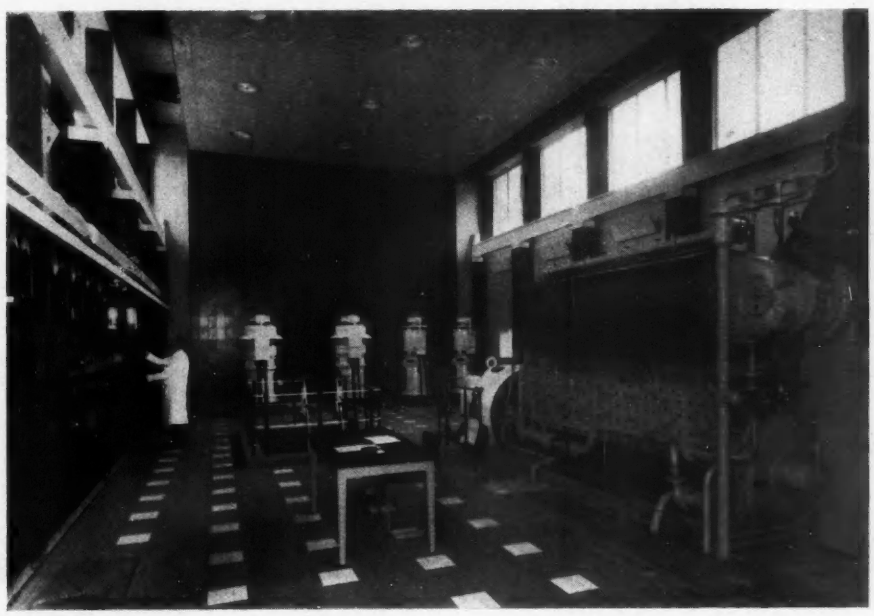




The 73-mile length of the Haweswater aqueduct marked *BDE* (left) was inaugurated by Manchester Corporation Waterworks (chief engineer, Mr. A. Atkinson) last June. The complete scheme will yield 105 m.g.d. and supplements the earlier Thirlmere supply to Manchester. Most of the new works are underground, but we illustrate above one of the reinforced concrete siphons on the route—the Beela siphon, near the Haweswater end. The first stage works—Haweswater dam, 9 miles of aqueduct (*AB*) and the 2½ mile connecting link (*BC*) were brought into use in 1941. The complete aqueduct comprises 31 miles 8ft 6in diameter concrete-lined tunnel, 8 miles of "cut and cover" channels, 4 miles of concrete single-pipe siphons and the first line of nearly 40 miles of steel multi-pipe siphons



The Hilfield park reservoir (left) forms part of a £3,000,000 scheme of the Colne Valley Water Company for the supply of 81 square miles of densely populated area in Middlesex and Hertfordshire. The reservoir is of particular interest as it will be used—for the first time in this country—for the storage of raw water from nearby wells in the chalk. The reservoir will be filled during the winter, when the yield from the wells is a maximum. The dam has a clay puddle core wall; its maximum height is 50ft, and its length half a mile, and the reservoir capacity is 600 m.g. Consultants, John Taylor and Sons; contractor, W. and C. French, Ltd.



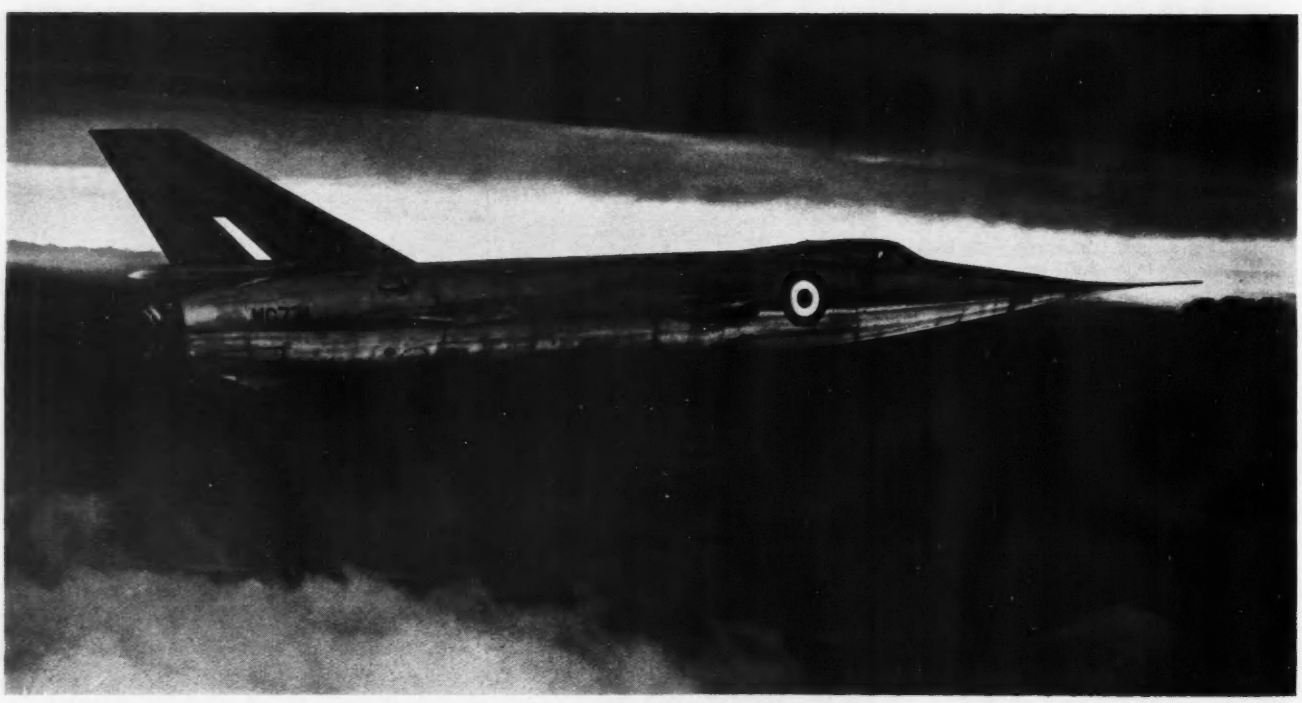
Sawbridgeworth pumping station (right) also gives a supply from wells in the chalk, and is in an area quite close to the heavily utilised resources of the Colne Valley. It has been built by the Herts and Essex Water Company and will yield about 2 m.g.d. The interior of the station is shown here as a representative example of the best modern practice in pumping station design and architectural treatment. There are two 60,000 g.p.h. borehole pumps in the shaft below the station, which is 170ft deep, and two surface force pumps of the same capacity in the building itself. The four pump motors can be seen in the background of the illustration. They are normally powered from the grid, but a stand-by diesel-driven alternator is also installed, as may be observed in the foreground. The illustration also shows the control panel for all the equipment, on the left, and gives a good idea of the architectural treatment of the interior of the pumping station

MILITARY AIRCRAFT OF 1955

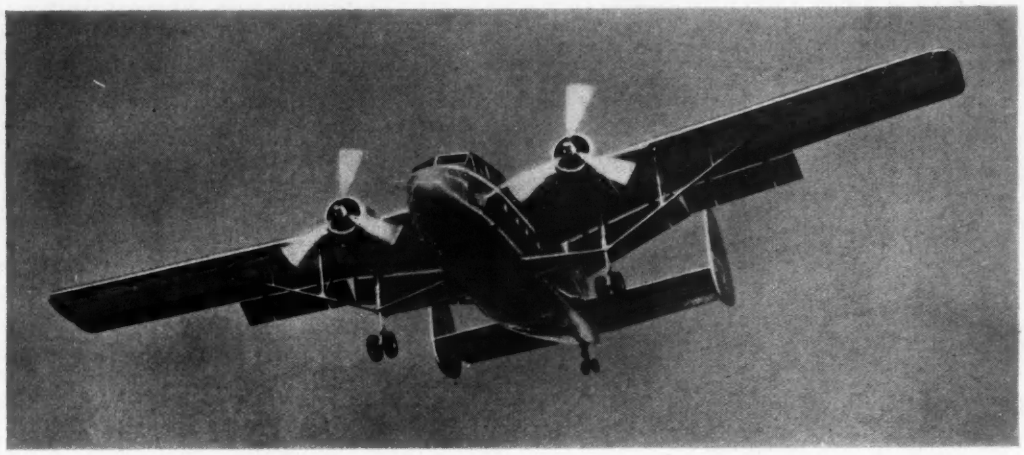
The Fairey Ultra-Light Helicopter is designed for use with advanced units of the Army. It carries a crew of two, and for artillery spotting or reconnaissance the second member can face aft, so that a full 360 deg. arc of vision is under observation. The engine, a Blackburn-Turbomeca "Palouste," can be started by hand, and delivers compressed air to the rotor head and along the blades to burners at the tips, which expel it tangentially. The turbine exhausts rearward and a rudder dips into the efflux stream; in straight flight it has to provide only sufficient yawing moment to counter the friction in the hub bearings. For transport purposes the machine can be manhandled or carried on an Army truck; the tail boom is easily folded, while the rotor is about 28ft tip to tip

First of a number of new fighters designed for the Bristol "Orpheus" engine is the Folland "Gnat." Considerations of logistics have dominated its design, and it is claimed to have a great advantage in cost and speed of production over contemporary interceptors. Its performance is comparable while the manœuvrability is superior. The armament consists of two 30mm Aden guns. A projected carrierborne version will be small enough to dispense with wing folding when passing through the deck lifts

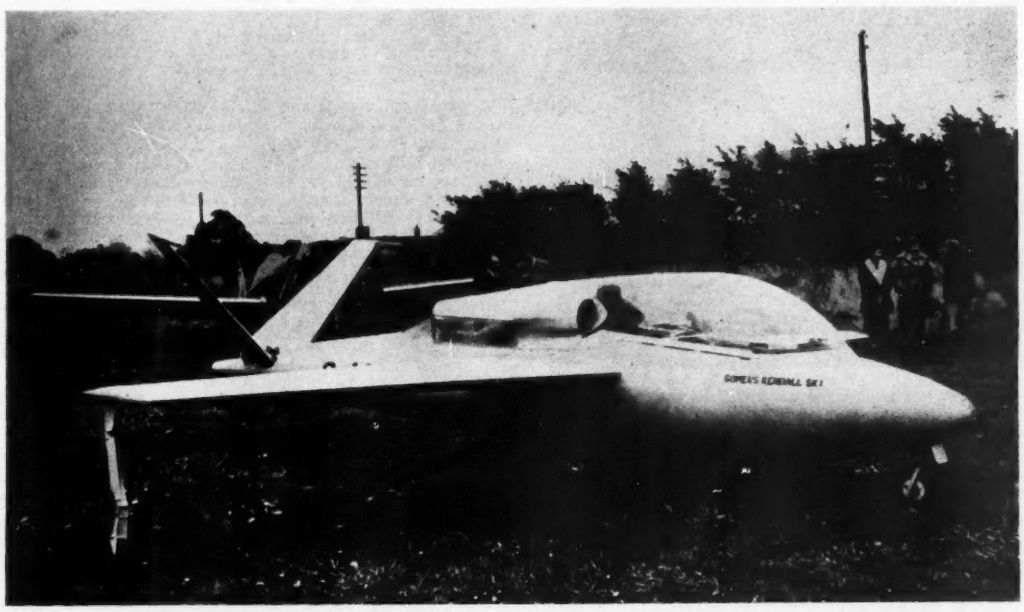
Uncompromisingly designed for high performance is the Fairey "Delta 2" with a Rolls-Royce "Avon" incorporating reheat, capable of supersonic flight with power to spare. In the illustration below the variable area jet nozzle is seen partly closed; also visible are the air brakes on the rear of the fuselage. Showing faintly against the fuselage is the boundary layer fence on the upper surface of the wing. The join in the fuselage immediately behind the cabin, where the nose hinges down for improved vision when landing, can also be distinguished



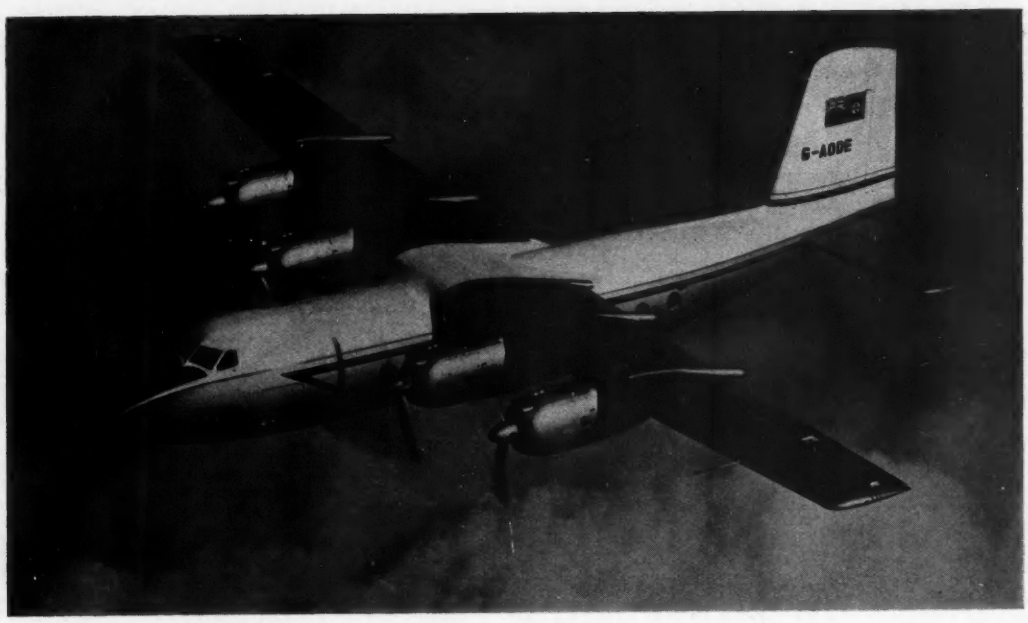
CIVIL AIRCRAFT OF 1955



Over a large portion of the world, adaptability to poor airfields and inadequate facilities is the most important quality of a commercial aircraft The Scottish Aviation "Twin Pioneer" (top) with 540 h.p. Alvis "Leonides" engines, brings to operators on primitive fields the ability to carry 1½ tons of cargo. The outstanding take-off and landing characteristics stem from large Fowler flaps, coupled to slats on the leading edge of the outer wings, while fixed slots are included in the centre section. It lands at 48 m.p.h. and can cruise at 174 m.p.h.; its service ceiling, of 20,000ft or 8000ft single-engined, should be adequate in most territories



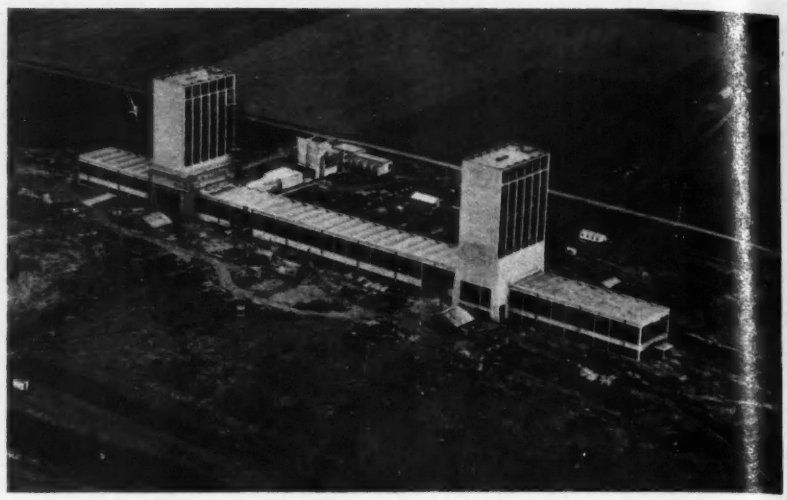
The Somers-Kendal "S.K.1" (centre) also seeks aerodynamic efficiency, but conservation of power is its object. It reflects many features of sailplane design, having a shoulder wing with an aspect ratio of eight, designed for laminar flow. Ailerons running the full length of the wing act also as flaps. The tail comprises two moving surfaces set perpendicularly combining the functions of stabiliser, fin, elevator and rudder; tabs are also fitted. Dive brakes and a landing parachute are fitted. The engine is a Turbomeca "Palas" of 350 lb thrust, and compressor delivery pressure retracts the undercarriage. The engine can be started electrically, a set of silver-zinc batteries being carried. While designed originally as a racing aircraft, the "S.K.1" includes dual control to allow it to be used as a trainer; 50 gallons of fuel offer over two hours' cruising at 25,000ft.



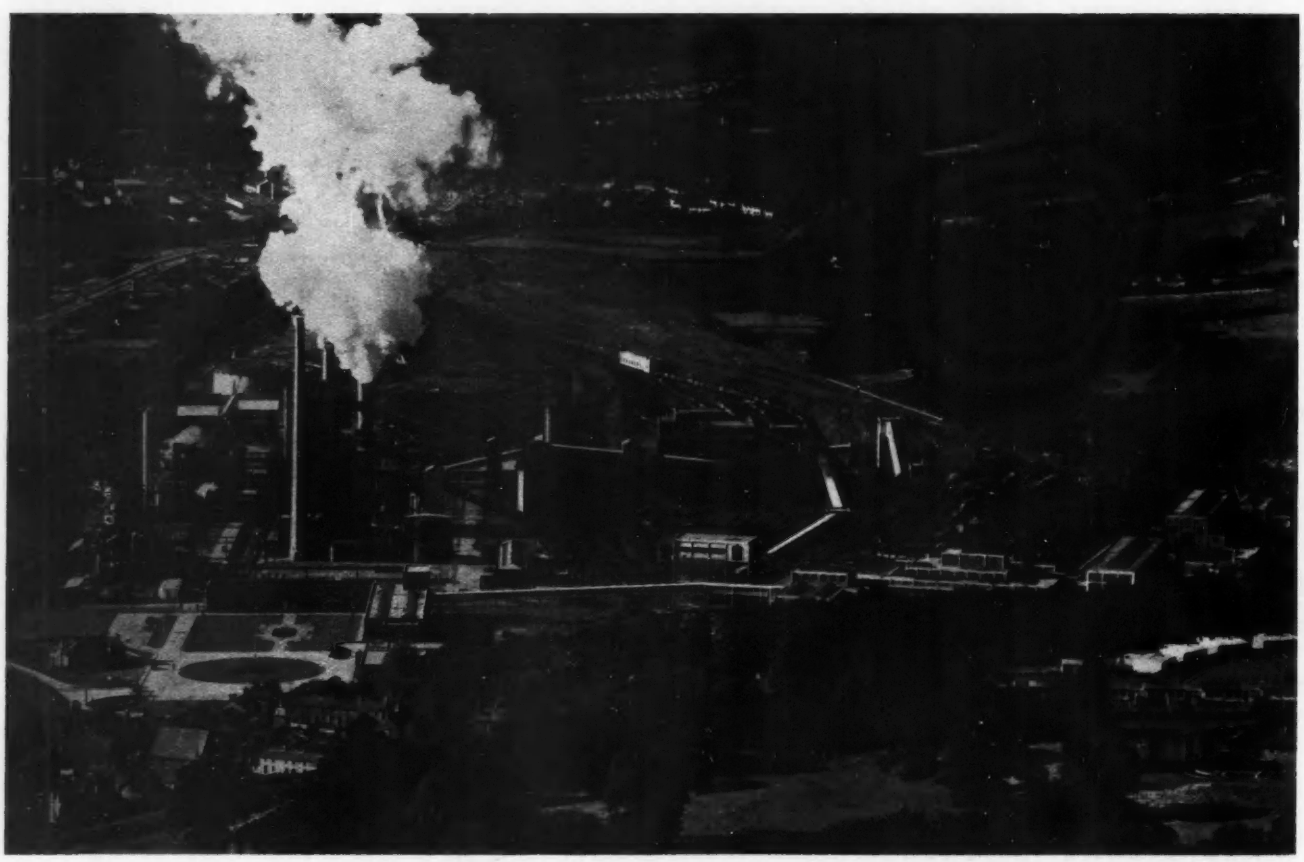
The Handley Page "Herald" (illustrated here) aims at efficiency as a revenue earner. It can carry loads ranging from forty-four tourist passengers to nearly 5 tons of freight; it has a tricycle undercarriage and rests with its floor level about 3ft 6in from the ground. It is normally operated by a crew of two, and can operate stage lengths as high as 1800 miles, cruising at nearly 200 m.p.h. It is powered by four Alvis "Leonides" Major engines of 870 h.p. and reversible pitch airscrews are optional

PROGRESS OF NEW COLLIERIES IN 1955

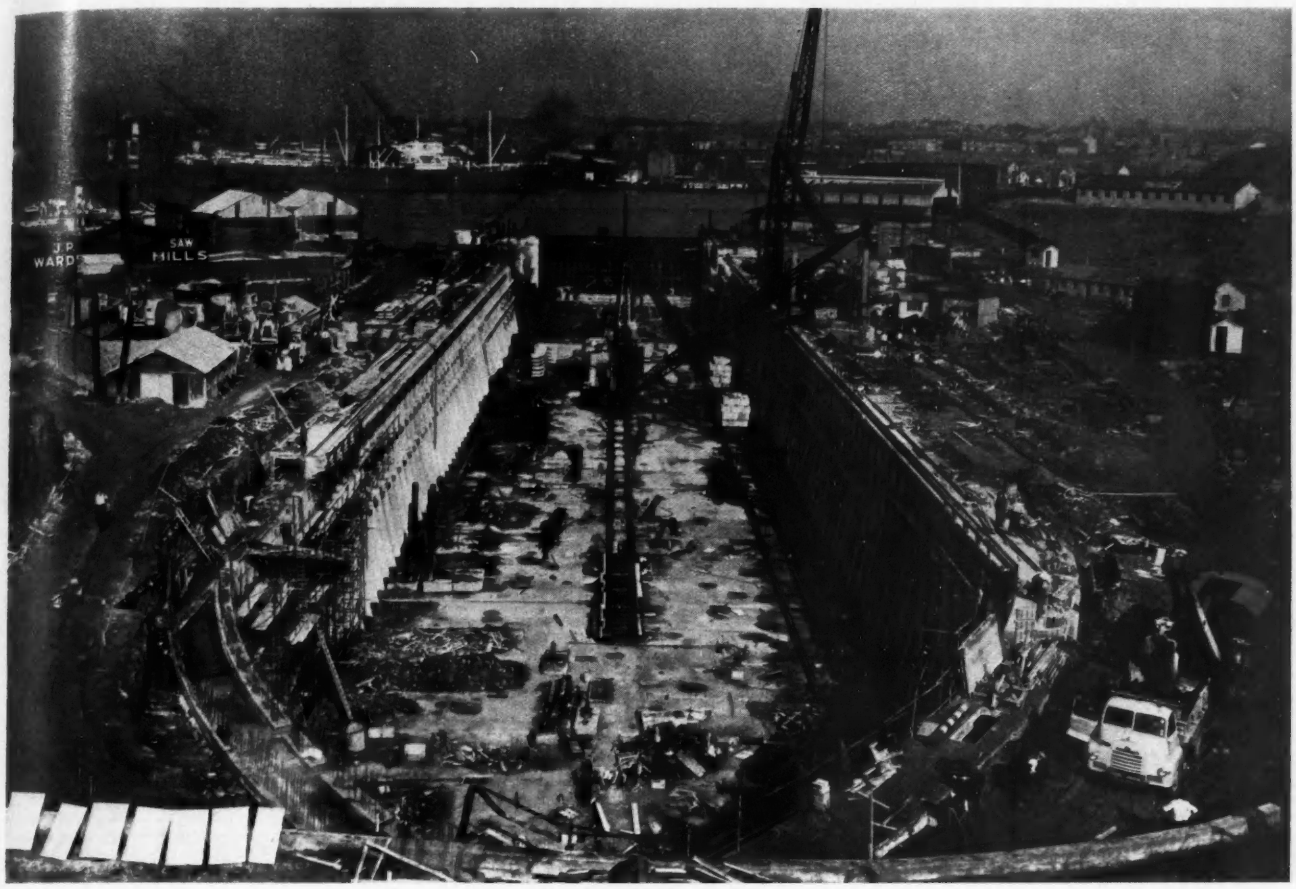
The off-shore boring tower shown below has been built for the National Coal Board to prove coal seams lying under the Firth of Forth, which will be worked from the colliery under construction at Seafield. A bore-hole 3000ft deep, 1½ miles off-shore was completed during the year. The tower is floated out and sunk in position for boring. The tower structure is of welded tubular steel, 120ft high. Consultants, Messrs. Maunsell, Posford and Pavry; contractors, Cleveland Bridge and Engineering Co., Ltd., and the Foraky Boring and Shaft Sinking Co., Ltd.



The National Coal Board's considerable programme for developing the coal mining industry is exemplified here by two new collieries. Rothes colliery in Fifeshire, shown above, is a fine example of modern layout. The two winder towers are of reinforced concrete construction, with an internal tower of structural steel, and the winding headframes are enclosed. Shaft sinking was in progress during the year, and considerable difficulty was experienced due to heavy inflows of water. Production is not expected to start for some years, but eventually about a million tons of coal a year will be won at Rothes, it is estimated. The general view of Nantgarw colliery below shows the pithead gear, coal preparation plant, and to the left, a carbonisation and by-products plant. A particularly clear impression is given of the layout, of rail sidings, the conveyors, and so forth. The coal preparation plant was brought into use in the middle of 1955. It is of interest because it can deal with the whole of the run-of-mine output in two processes only—heavy medium (" Chance ") and froth flotation—as developed by the Fraser and Chalmers works of G.E.C. Nantgarw colliery will eventually produce about 800,000 tons of coal each year, but it is not yet in full production. The output for 1955 was about 220,000 tons



CIVIL ENGINEERING IN 1955

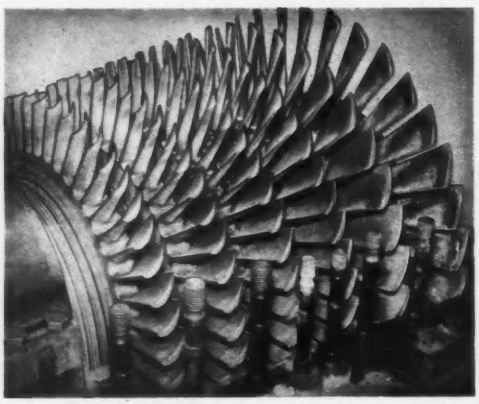


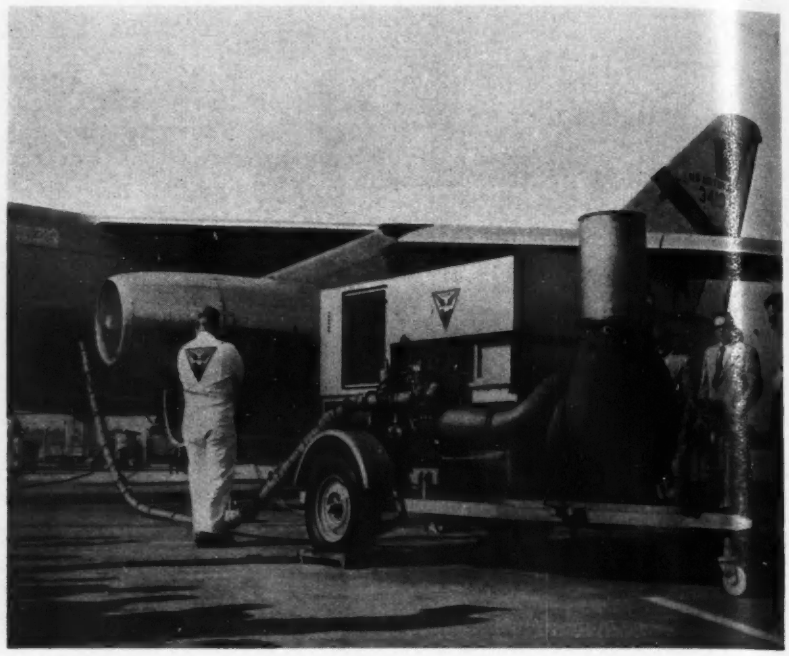
The dry dock at South Shields, shown under construction above, will be the largest dry dock on Tyneside when completed early next year, and will accommodate tankers of 38,000 tons deadweight. It is of particular interest because of the use of precast concrete cantilever buttresses to form the walls; this construction is explained in the accompanying annual review of civil engineering. The dock is being built for Brigham and Cowan, Ltd. Consultants, G. Maunsell and Partners; contractor, Marples, Ridgway and Partners

The Neath by-pass bridge and viaduct in South Wales (below left) is the only sizeable bridge work to be completed in this country since the war. It was opened last November and comprises a viaduct of eleven spans, 972ft long, followed by a short cutting, which are not shown in the illustration; then comes the main structure as shown, which is 1610ft long, with seventeen spans. The river crossing has a central span of 300ft, and two side spans (cantilever anchor arms) of 140ft, and gives a clearance of 90ft above high water. Consultants, Rendel, Palmer and Tritton; contractor, Cleveland Bridge and Engineering Company, Ltd.

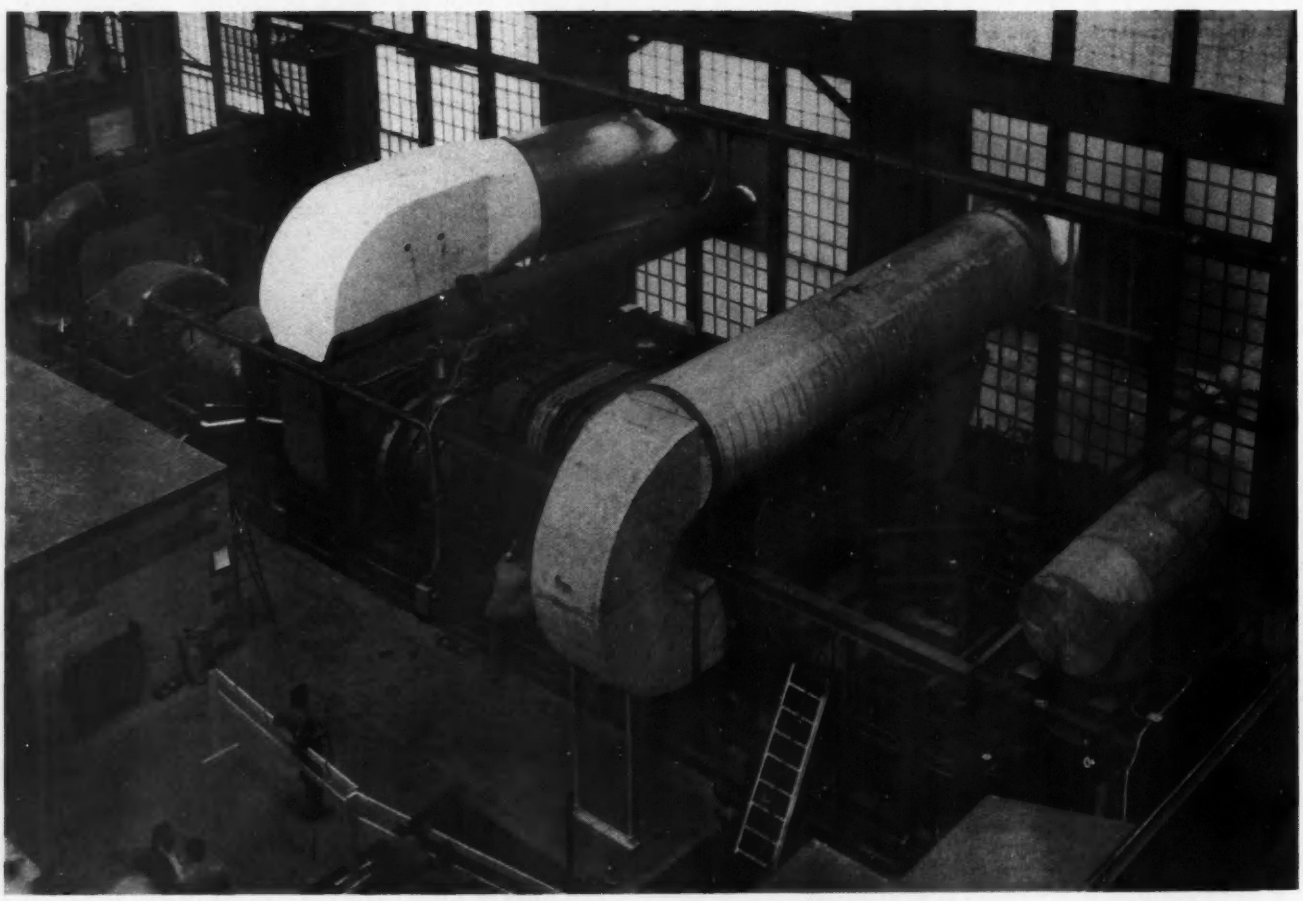
The Allt-na-Lairige dam (maximum height 83ft) of the North of Scotland Hydro-Electric Board is shown (right) at a stage reached early in 1955. The dam is prestressed by a series of vertical ties anchored at the crest, and in pits below the heel of the dam. Twenty-eight 1¼in diameter steel rods at each anchorage give a prestressing force of 1176 tons (56 tons per foot run). The use of prestressing enabled the storage capacity to be increased from 8·3 to 10 per cent of the average annual run-off, for the same cost as the original gravity design. Consultants, Babtie, Shaw and Morton; contractor, Marples, Ridgway and Partners, Ltd.

UNITED STATES GAS TURBINES IN 1955



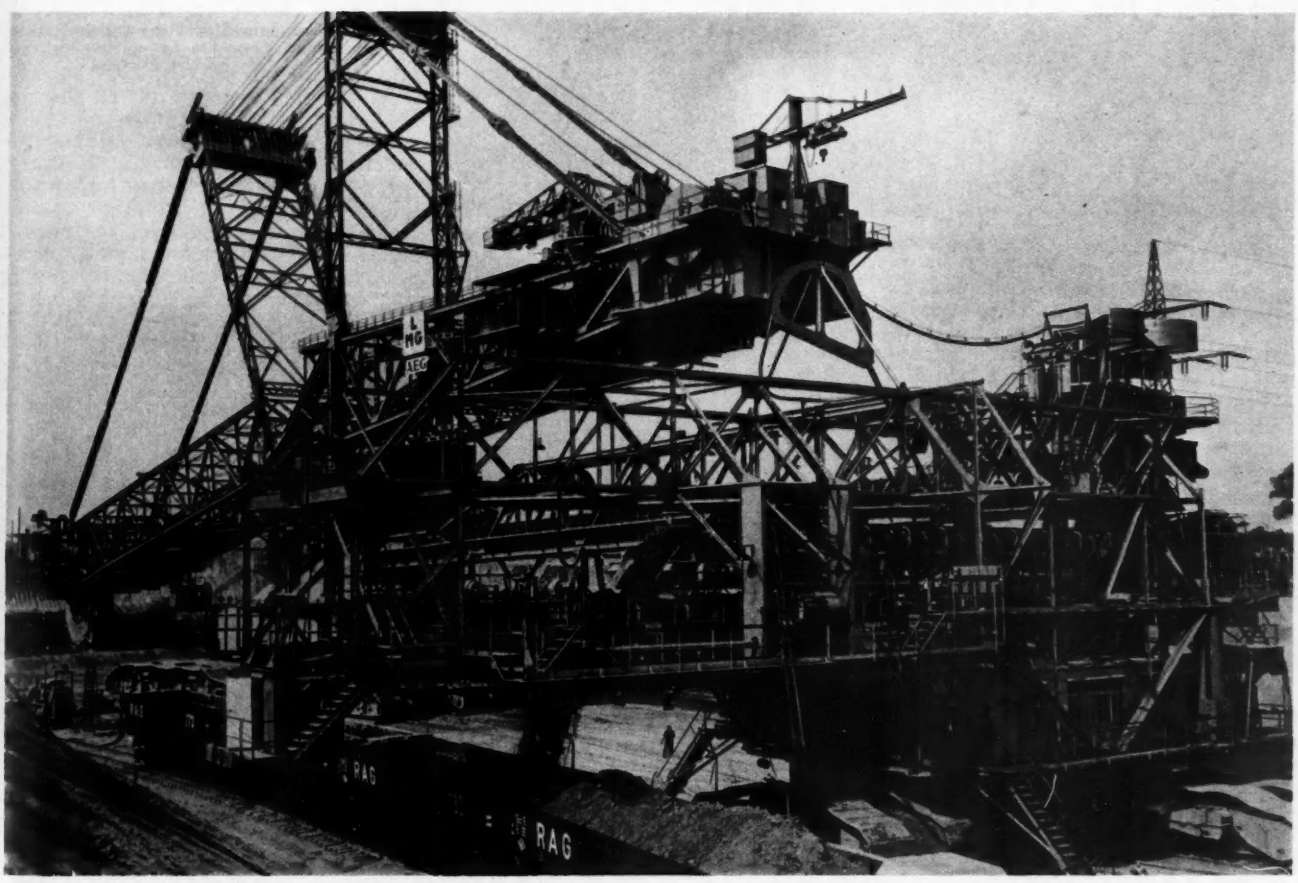


During its 1955 test programme the Locomotive Development Committee of Bituminous Coal Research, Incorporated, tested its 3540 h.p. stationary coal-burning gas turbine plant at load factors in excess of normal locomotive operating practice. 1421 hours of coal-fired operation was achieved in 83 days; 4,111,400 horse-power hours were generated at an average load of 2894 h.p., and 2250 tons of bituminous coal were burned. Normal turbine blade wear was confined to 0·005in to 0·010in on the concave surfaces, and abnormal localised wear (illustrated above left) was confined principally to the roots of the third and fourth row blades, where notches exist in the trailing edges. These notches served as stress concentration points, from which cracks extended partially across a total of twenty-seven blades. The T-300J-1 aircraft ground power unit now being built by the Solar Aircraft Company exploits an interesting field of application for the smaller gas turbine. As shown (above right), it incorporates a "Jupiter" T-520 500 h.p. gas turbine engine having a dry weight of 449 lb. The unit furnishes aircraft on the ground with: compressed air for engine starting, 2·5 lb per second at 53 lb per square inch absolute; electric power, 90kVA at 400 c/s, 120/208V; hydraulic power, 10 gallons per minute at 3000 lb per square inch; and cooled or heated air for flight deck air conditioning, 2000 lb per hour at 40 deg. or 150 deg. Fah. The first three requirements can be concurrent; the air for flight deck conditioning can be interrupted during engine starting. The mobile 5500kW gas-turbine-electric power plant shown below undergoing works tests has been developed by the Clark Brothers Company, for the U.S. Navy Bureau of Yards and Docks. It is mounted in a railway wagon and can be placed in operation after very little preparation. The source of power is a simple, open cycle, dual shaft, series-flow gas turbine directly connected to a two-pole synchronous generator. The gas turbine consists of an axial-flow turbine with two shafts. The first turbine, consisting of two stages, drives the axial-flow compressor supplying combustion air. The second turbine, running independently, drives the generator directly at 3600 r.p.m. The thirteen-stage axial-flow compressor is driven through a flexible coupling by the high pressure turbine at 5000 r.p.m.

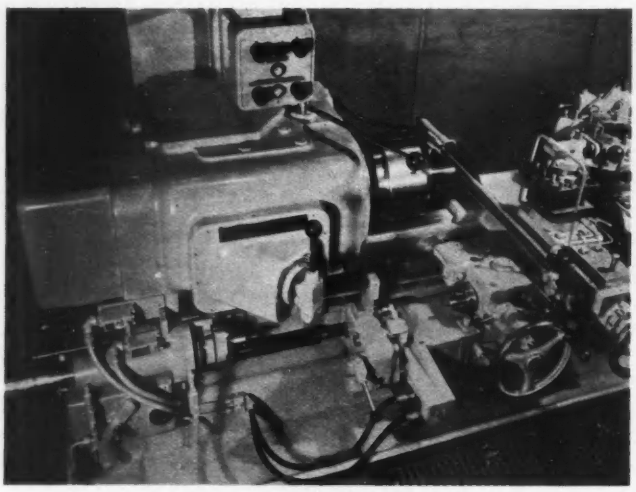


LARGE BUCKET EXCAVATOR FOR A GERMAN LIGNITE MINE

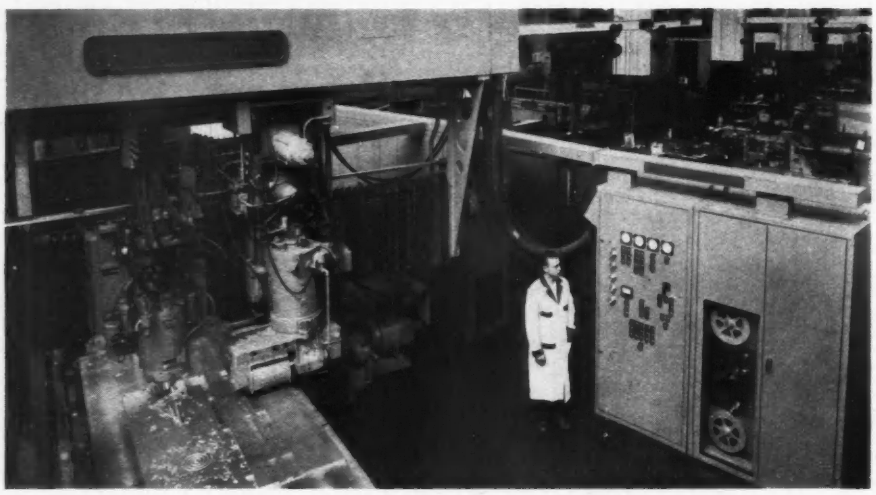
In August, the first of a group of five very large bucket wheel excavators came into service at the opencast mine "Fortuna," west of Cologne, which belongs to the Rheinische Aktiengesellschaft fuer Braunkohlenbergbau und Brikettfabrikation; 200m long, 66m high, and having a capacity of 100,000 cubic metres per 19½-hour day, the machine is the largest of its kind in existence. It was built by Orenstein-Koppel und Luebecker Maschinenbau Aktiengesellschaft with electrical equipment by Allgemeine Elektricitaets-Gesellschaft and weighs 5600 tons, including 170 tons of material on the conveyor belts. The bucket wheel (right), with its twelve 3·6 cubic metre buckets, is driven at 2·3 r.p.m. by two geared, 3kV slipring motors, each of 525kW. The entire machine comprises three main sections, the excavator itself, the conveyor bridge, and the wagon loading station (lower illustration). Both the excavator and the loading station move on caterpillar tracks of sufficient area to limit the average ground pressure to 1·25 kg per square centimetre, the excavator on three groups of four tracks, and the loading station on three groups of two. Powered by d.c. motors, the machine can move at up to 600m per hour, and each portion can turn in a 100m diameter circle. The jib can be raised to 50m above track level and lowered to 6m below, by means of a twenty-four-purchase block operating the topping boom. Two independent winches are provided to increase safety and enable the 59mm thick wire ropes to be changed without propping up the jib. The superstructure is supported on the central portion by a 15m diameter slewing ring containing 156 ball bearings of 150mm diameter. A similar ring supports the central part on the chassis. In this way the counterbalanced superstructure can turn through a full circle, and the conveyor bridge, one end of which slides in the central portion, can be arranged independently of the tracks. The central excavator section also houses a coal crusher, which can be moved into position when required and serves to limit the coal size to 500 millimetres. From the bucket wheel, near which is the driving cabin, band conveyors, 2·6m wide, carry some 2 cubic metres per second of material to the loading station. There, the overburden is loaded into wagons holding 180 tons, while for coal, wagons of 93 tons capacity are provided. The two reversible loading conveyor bands are alternately supplied from a swinging intermediate conveyor. Each of the two rail tracks is supervised by one loader, who radio-controls the 129-ton electric locomotives. Apart from a few maintenance men, the excavator thus requires three operators—the driver and the two loaders. Rated at a total of 10,300kVA, the installation is supplied at 25kV by a 24-ton trailing cable 1500m long. It is intended to equip the machine with programme control so that slewing cuts 10m high, 1·2m deep, and 89m wide can be taken automatically. Bucket wheel excavators are stated to have been chosen as being most suitable for the irregular coal seams of the district. The mine aims at an output of 25,000,000 tons of lignite per year (5·4 per cent of 1954 world lignite production), and will eventually reach a depth of 250m



MACHINE TOOL "AUTOMATION" IN THE UNITED STATES IN 1955



With the electronic numerical sequence programmer (right) for lathes, which is made by the Monarch Machine Tool Company, up to five automatic work cycles using up to five spindle speeds and five feed rates can be set for repetition production. An electronic control panel works with an analogue-to-digital converter, which is connected to the carriage motion of the machine tool and actuates the control circuits at intervals in the automatic cycle for the various operations. The Jones and Lamson "auto threader" (left) is a typical American attachment used with standard machine tools to impart automatic operation. This device on a standard turret lathe provides a fully automatic thread chasing cycle for a single-point tool



The machining versatility of the Giddings and Lewis "Numericord" system of machine tool "automation" are shown by the plunge, channel and pocket milling cuts performed by this spar and skin milling machine under complete control of a numerically prepared magnetic programme tape. To the right of the machine attendant is the magnetic tape playback unit, which is capable of simultaneously controlling as many as five machine axes in three dimensions and up to twenty-two auxiliary machine functions

The Norton transfer crankpin grinding machine illustrated is a good example of a fully automatic cylindrical grinding installation which eliminates the operator's manual duties of inserting, clamping, adjusting, controlling, gauging and removing the crankshaft from the machine. The automatic handling and grinding cycle is repeated at each station as the crankshaft is transferred from one grinding station to the next and finally to the conveyor line. Automatic truing of the grinding wheels occurs at predetermined intervals and compensation for the reduced wheel diameter after truing also occurs automatically. The machine is built in sections consisting of two stations. Each station comprises a grinding wheel head mounting a 42in diameter grinding wheel and a pair of work heads

James Williamson and Partners, and Kennedy and Donkin.

The North of Scotland Hydro-Electric Board's constructional works of 1955 are exemplified by the Allt-na-Lairige dam shown on Plate 13 and by the accompanying illustration of Lairg dam of the Shin scheme in Sutherland. The Shin scheme will generate about 150 million kWh annually, from plant of 43MW capacity. The consulting engineers for the civil engineering works are Sir Murdoch MacDonald and Partners and the contractors George Wimpey and Co., Ltd., R. and J. McLeod (Contractors), Ltd., and William Tawse, Ltd.

The dam is a gravity concrete structure with embankments at each side with concrete core walls. It will enlarge Loch Shin to provide the main storage reservoir of the scheme. A small power station (3·5MW) is associated with the dam, below which is a forebay, with diversion works to the principal power station which has 24MW capacity. There are also upper stage works on each side of the loch, with power stations at Cassley (10MW), Garvault (1MW) and Ben Hee (5MW).

The year's achievements in the North of Scotland were summed up in a speech given by Mr. Fulton, the general manager of the Board, on December 22nd. 1955 had been a special year in a number of ways, he said. It had been a particularly dry year especially in the eastern half of Scotland, and rainfall had been very much lower than that shown by any records. That had entailed careful husbandry of resources of water and a reversal of the flow of energy from the south to the north. The same problem had also faced water undertakings. The year had also been of special interest because of the number of stations put into commission, Mr. Fulton continued. Clachan power station, with a capacity of 40MW, was put on load early in the year; Sron Mor and Allt-na-Lairige stations would come on later in 1956. At Torr Achilty, a second 7·5MW set was put on load, and at the Errochty station the first 25MW set was commissioned, and the other two sets were being made ready for running, Mr. Fulton noted. At Finlarig, a 30MW set was nearly ready and in Glen Garry, in Inverness-shire, the Quoich station of 22MW capacity was also in operation. Lower down the glen, the Invergarry power station, which has a high head Kaplan turbine, was due to be taking water, perhaps before the year was out. The small underground power station in the Mullardoch tunnel had also been commissioned. All told, Mr. Fulton concluded, there had been added by December 22nd 128MW of plant with a further 20MW at Invergarry and 50MW at Errochty nearly ready.

Tunnels

The continuation, over a period of years, of rock tunnelling contracts for the North of Scotland Hydro-Electric Board's schemes has given a stimulus to the productivity of this class of work and two record drives were claimed during the year—444ft in seven days on the Allt-na-Lairige scheme last May, by Marples, Ridgway and Partners, Ltd., and 557ft in seven days last October by the Mitchell Construction Company, Ltd., on the Breadalbane scheme. These high rates of progress result from improved equipment, careful planning of the cycles of operation and well-trained tunnelling crews. The equipment used on the Allt-na-Lairige drive was described in THE ENGINEER of May 20, 1955.

Tunnelling in the London Clay is being carried out for the Metropolitan Water Board on the scheme for a large main from the Thames to the Lee Valley and some other similar works. Economies are being effected by using deep tunnels as raw water conduits, and by replacing the cast iron lining constructed for such works up till recently (with a pipe inside it for water tunnels) with a concrete lining, in which a lining ring is formed by placing in position a number of precast segments, wedge-shaped or with a wedge-shaped key. This method of construction was introduced some years ago, but last February the final stage in a comprehensive series of tests was reached with the presentation of a paper at the "Civils," namely, "Investigations into the Design of Pressure Tunnels in the London Clay," by F. Tattersall, T. R. M. Wakeling and W. H. Ward (see THE ENGINEER, February 25, 1955). It was shown that this new method is reliable, under the conditions encountered in a deep tunnel in London Clay. Considerable economies will result from its use and it was stated that a saving in capital cost of about £1,000,000 would result on the Thames-Lee Valley tunnel. In a second case, where a deep tunnel replaces a surface conduit and pumping station, about £1,750,000 will be saved.

One other series of tunnelling works should be mentioned, but for obvious reasons the only information we can give is by quoting from the speech on estimates made by the Air Minister, Lord de L'Isle and Dudley, in the House last February. The largest single project at home had been the reconstruction of the radar chain, he said. It covered the whole of the United Kingdom. Hundreds of new installations had been built and vital parts of the system had been put deep underground and protected by massive thicknesses of concrete. The extent of the work on any one underground installation was not much less than that involved in building a new tube railway station.

(To be continued)

Naval Construction in 1955

By RAYMOND V. B. BLACKMAN

No. I

Great Britain

IN 1955 it was evident that the long period of post-war study by the Admiralty to decide our future naval construction was terminating and that practical steps were being taken to end the big ship building holiday (no aircraft carriers, no battleships, no cruisers, no destroyers, in fact no major warships of any kind having been ordered since the end of the second world war in 1945, although five aircraft carriers and eight "Daring" class ships ordered during the war have been completed during those ten years). It was decided that guided missile ships are to be built and also under the 1955–56 Navy Estimates two fleet escort ships which will embody the newest developments in the destroyer field are to be ordered (together with eight frigates and ten coastal minesweepers).

The year was also notable for the delivery to the Royal Navy of the first fruits of the naval rearmament programme initiated in 1950 in the shape of the first two anti-submarine frigates. A large number of smaller and highly specialised minesweepers, fast patrol boats and seaward defence craft were completed. And a considerable proportion of the Admiralty's shipbuilding effort was devoted to the reconstruction, conversion and modernisation of older warships.

The highlight of naval construction in 1955 was the final completion of the large fleet aircraft carrier "Ark Royal," which, with her near sister ship "Eagle" and the intermediate fleet aircraft carriers "Albion," "Bulwark" and "Centaur," completed in 1954, now collectively constitute the mainstay of the Fleet, since all the older aircraft carriers have been placed on the disposal list or withdrawn from operational service, our five surviving battleships have been relegated to reserve, and so few of our ageing cruisers remain in active commission.

The "Ark Royal" was built at the Birkenhead shipyard of Cammell Laird and Co., Ltd., and is the largest ship ever constructed by that firm. The building history of this latest aircraft carrier covers a period of some twelve years. She was laid down on May 3, 1943, but after the cessation of hostilities her construction was not pressed and she lay on the stocks for exactly seven years. The opportunity was taken, however, to embody all the lessons of the war in her, and to a large extent her design was recast to keep pace with the development of modern naval aircraft, and to anticipate the requirements of aircraft and naval operations of the future. So it was not until May 3, 1950, that the "Ark Royal" was launched.

On February 22, 1955, the first aircraft carrier to have all the post-war developments in flight deck technique, and the largest aircraft carrier ever built for the Royal Navy, was commissioned under the command of Captain D. R. F. Cambell, D.S.C., R.N., an officer directly concerned with the conception of one of the most important of these developments, the angled deck; and on February 25th H.M.S. "Ark Royal" put to sea for her acceptance trials.

With more than fifty aircraft embarked (the wartime complement of aircraft would be greater, her full capacity being eighty to one hundred, according to size and type) the "Ark Royal" is the most formidable fighting unit of the Royal Navy, for in her the full dividend of naval research and development is being reaped. Not only has she the angled deck, but also two steam catapults, a new type of arrester gear, a deck edge lift in addition to central lifts, the mirror deck landing aid, hangars with an improved type of ventilation, and a special air crew refreshment centre. This combination of several innovations in aircraft carrier technique will enable her to fly off and land on the fastest and heaviest types of aircraft envisaged in naval warfare and to operate them more rapidly and with greater safety than any previous aircraft carrier; and her effectiveness in the mounting of seaborne attack will be unsurpassed by any comparable ship.

With a nominal standard displacement of 36,800 tons and a full-load displacement of 46,000 tons the "Ark Royal" has a length between perpendiculars of 720ft, an overall length of 808ft 3in, a water line beam of 112ft 9in, an overall beam of 158ft, and a maximum draught of 36ft. Her flight deck has an area of 2 acres. Only two British warships have ever displaced more than the "Ark Royal," namely the late battle cruiser "Hood" and the battleship "Vanguard."

During construction modifications were made to the design of the "Ark Royal" with the object of improving not only her fighting abilities but also her accommodation; and the completion of the ship was still further delayed in order to allow her to be fitted with the 5½ deg. angled deck. Although the optimum angle is some 3 deg. greater, the alterations to the ship did not need to be so extensive as those which would have been required for the full angle, and the value of the interim angle in reducing accidents has already been proved in the new aircraft carriers of the "Centaur" class. Steam catapults are installed operationally in the "Ark Royal" for the first time, and they fulfil all the foreseeable requirements for aircraft launching.

The improved form of arresting gear with which the ship is fitted is more robust and therefore capable of keeping pace with the new steam catapult in the size of aircraft landed on. The advent of the angled deck has permitted the number of wires, on to which the aircraft are hooked, to be reduced to six. Crash barriers will only be used in the rare event of an aircraft losing its hook. Before the introduction of the angled deck they had to be in position throughout landing periods to protect the aircraft parked forward.

The "Ark Royal" has the first deck edge lift to be installed in an aircraft carrier of the Royal Navy. This lift is situated amidships on the port side and serves the upper hangar, and there are two more lifts on the centre line. This new arrangement contributes in a major way to the flexibility of the flight deck work and to the speeding up of flying operations. The improved ventilation in the hangars, coupled with the reduced danger arising from the use of kerosene for jet aircraft, greatly facilitates aircraft maintenance work. When aviation spirit was in use in the old style hangars it was necessary to hold up maintenance activities throughout the hangar when there was any likelihood of sparks igniting the fumes. In the hangars of the "Ark Royal" only a small section near an aircraft being refuelled has to be treated as a "fuel danger" section.

The "Ark Royal" has mirror deck landing aids on both the port and starboard sides. These aids are becoming more and more important with the introduction of aircraft possessing high approach speeds. Moreover, it has already been proved that they reduce the risk of accidents during landing on. The introduction of an air crew refreshment centre enables pilots and observers to rest and refresh themselves before a flight. In previous aircraft carriers they had to travel some distance and climb down a number of steel ladders for their meals, and a not inconsiderable strain was thus imposed upon them at a time when it was desirable for them to conserve their energy, and there was the possibility of delay if they were suddenly required for an unexpected operation.

All the experience gained at sea in the second world war was embodied in the planning and construction of this great floating airfield. To produce the best results in operations of the future, every case of action damage of the past was studied and where existing practice was shown capable of improvement a change was made. In constructing the hull of the new ship electrical welding was used on the widest possible scale to provide the lightest and strongest structure possible, although there were many parts of the "Ark Royal" in which the highest quality of the riveter's art proved to be essential. Fuel for the aircraft is stored in several groups of tanks dispersed throughout the ship in such a manner as to reduce the risk of fire to a minimum. Magazines for storing all types of airborne weapons are in other protected parts of the ship, from which projectiles such as heavy bombs can be raised by a special lift.

Large dining halls are supplied from galleys containing the most up-to-date machinery and electrical cooking equipment. Messdecks are furnished with settees and tubular tables and chairs. There are excellent laundry facilities installed with modern electrically driven equipment comparable with that in a big laundry ashore. The distilling capacity of the ship is 350 tons of fresh water per day.

Cammell Laird and Co., Ltd., was responsible for the main propelling machinery which comprises four sets of Parsons single reduction geared turbines together developing some 152,000 s.h.p., taking steam at a pressure of 400 lb per square inch and a temperature of 600 deg. Fah. from eight Admiralty pattern boilers of the three-drum type and turning four screws to give a maximum speed of 31·5 knots. This plant constitutes the most powerful and efficient main engine installation ever designed for a British warship and is of a type which will give the ship a continuous high speed and ensure that special degree of mobility which is required in an aircraft carrier. The "Ark Royal" is the first ship to be fitted with remote control of engines and boilers for use in the event of atomic attack at sea. The remote control compartments are equipped with all the controls normally associated with the engine-room platform and all the means of steaming the boilers and running the turbines and auxiliary machinery, an array of pressure and temperature gauges, switches, boiler water level glasses, valves and universal joints, throttles and direct lines of communication. With no one manning the engine-rooms, but by means of these remote control panel stations, the "Ark Royal" has been brought to anchor in Sandown Bay, off the Isle of Wight. The Senior Engineer said that the use of remote control had proved to be very successful. He said it could be the normal method of steaming, and it reduced the manpower required for the task. If an atomic attack were made on the fleet and the "Ark Royal" was within the "fall out" area she would immediately be "sealed," which means that she would cease to draw in ventilation air from the atmosphere, the air already inside the ship being recirculated, and all the ship's company would quickly be withdrawn to safe positions, away from the danger of contamination. Without normal ventilation the temperature in the engine and boiler-rooms would soon become unbearable and all staff would be evacuated without delay, and the ship steamed by remote control from two emergency control rooms. Each of these stations can control two sets of turbines and two boiler-rooms. By means of the miniature levers and dials all the main propelling machinery can be operated as accurately as from the normal positions on the engine-room and boiler-room plates six decks below by a staff of eight in each remote control compartment, with one engineer officer on watch.

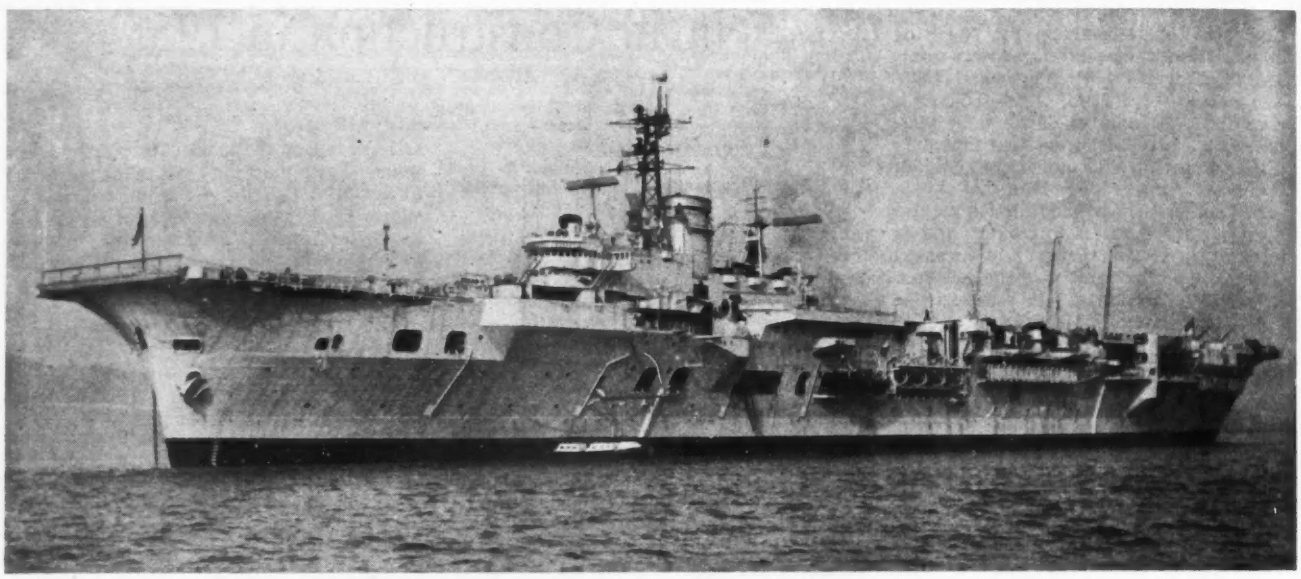


Fig. 1—H.M.S. "Ark Royal," Britain's largest aircraft carrier. Completed February 25, 1955

The armament of the "Ark Royal" comprises sixteen 4·5in dual-purpose guns in eight twin mountings, two on each side forward and two on each side aft on sponsons, forty-one 40mm Bofors anti-aircraft weapons in five six-barrelled mountings, two twin mountings and seven single mounts, and four three-pounders. All the latest radio and radar devices are fitted both for the navigation of the ship and for the control and direction of her guns and aircraft in both good and bad weather. The peacetime complement of the new carrier ranges upwards from 110 officers and 1522 ratings to a total of 1745 (including the ship's air complement, but excluding the complement of attached squadrons). With her front line aircraft embarked there are in addition approximately 100 officers and between 450 and 500 ratings (total complement 2295 to 2345).

A great deal of attention has been devoted to the photographic needs of the "Ark Royal," since photography is playing an increasingly important part in naval warfare, both operationally and for training purposes. Its scope extends from the reproduction of charts and documents to the photographing of large areas of territory from the air. It is used for the recording of all deck landings, of radar traces and instruments, and in association with, or even as an integral part of, modern weapons. Vibration free enlargers operate with the ship travelling at full speed and in any kind of sea. With the large stocks of material carried in refrigerated compartments, the "Ark Royal's" photographic section can serve as a central processing laboratory for other ships in a striking force, but as space is at a premium it is compressed into the smallest possible compass and designed to save weight, commensurate with meeting the large variety of demands, operating under adverse conditions, and carrying out processes quickly.

The only new aircraft carrier still under construction for the Royal Navy at the end of 1955 was the "Hermes," at the Barrow-in-Furness yard of Vickers-Armstrongs, Ltd. This ship was laid down as long ago as June 21, 1944, but it was not until February 16, 1953, that she was launched. The delay in her completion is due to a complete recasting of her originally projected design to incorporate new features and improved arrangements and equipment in line with post-war developments, including a full-angled deck, two steam catapults and a deck edge aircraft lift. According to again-revised dimensions and armament officially released by the Admiralty, the "Hermes" will now have an overall length of 741ft 6in, a length between perpendiculars of 650ft, and a water line beam of 90ft, and will be armed with seventeen 40mm anti-aircraft guns in seven twin and three single mountings, and four three-pounders. Her originally designed standard displacement was 18,300 tons, but it is now estimated that she will turn out at 22,000 tons standard displacement increased to 27,000 tons at full load, with an overall beam of about 130ft and a draught of 26ft.

With such size and displacement the "Hermes" no longer falls into the light fleet aircraft carrier category, in which she was initially conceived. She will be much superior to earlier ships of her class, so much so in fact that she has been officially disassociated from them. The "Hermes" originally gave her name to a class of four intermediate aircraft carriers, of which the "Albion," "Bulwark" and "Centaur" were completed in 1953-54, but so many changes have been made in the "Hermes" and such a number of modern improvements have been applied to her that she is no longer similar to the class which took her name, and her three erstwhile sister ships were, from last August, given a new name, being known as the "Centaur" class.

The main propelling machinery of the "Hermes" comprises Parsons geared steam turbines by Vickers-Armstrongs, Ltd., turning two shafts, developing 78,000 s.h.p., giving a speed of 28 knots, and fed from four boilers of Admiralty three-drum type. She will carry about forty-five aircraft, according to size and type, with a complement of 1400 officers and men.

Work is still suspended on the remaining two light fleet aircraft carriers which constitute the backlog of the second world war emergency programme, namely the "Hercules" and "Leviathan."

Guided Weapon Ships

It was also stated in the 1955-56 Navy Estimates that the guided weapon ship and the guided missile with its associated equipment were now far enough developed for the Admiralty to feel confident that it could proceed with the design and construction of operational ships, to replace our ageing cruiser fleet, and to make use of this powerful new armament. The guided weapon ship was revolutionary and would, it was believed, effect changes in certain types of naval warfare comparable to that once brought about by the introduction of the all-big-gun "Dreadnought," which rendered all previous battleships obsolete. The first operational ship application of the guided missile would be a purely ship-to-air weapon; but a system would be developed in the years ahead capable of operating a ship-to-ship weapon from the same equipment. In the first instance, therefore, the guided weapon cruiser would be armed with a very lethal ship-to-air guided weapon, which would very much improve our ability to defend ourselves against air attack even by the fastest modern aircraft; and a gun armament for surface gunnery, bombardment, and to supplement anti-aircraft fire. The ship would be so designed, however, that this gun armament could be replaced by the ship-to-ship guided weapon system when this became available. Rather than build more conventional cruisers, the Admiralty preferred to concentrate on the guided weapon ship which was in sight. This ship would be something over 10,000 tons displacement and an obvious successor to the cruiser.

Cruisers

To help close the gap before the guided missile ships came into service, the Admiralty has decided to complete the three long-delayed cruisers of the "Tiger" class with their modern gun armament. This was now ready and the new guns were almost entirely automatic and fired a new design of shell at a very high rate. They therefore felt justified in deciding to finish building these three cruisers begun over fourteen years ago. They would get for the money they spent in completing them three cruisers for approximately the price of one. The cost of resuming the construction of the "Blake," "Defence" and "Tiger" was about £18,000,000, which was equal to the price of a new cruiser built to-day. In 1939 the cost of a cruiser roughly the same size was only £2,000,000.

The keel of the "Tiger" was laid at the Clydebank yard of John Brown and Co., Ltd., as long ago as October 1, 1941, and she was launched on October 25, 1945; but work on her was stopped in July, 1946, and she was laid up at Dalmuir. The "Defence" was begun on June 24, 1942, by Scotts' Shipbuilding and Engineering Company, Ltd., Greenock, and she left the stocks on September 2, 1944, but construction on her, too, was suspended after the war and in this case the contract was cancelled and she was laid up in the Gareloch. The "Blake" was laid down by the Fairfield Shipbuilding and Engineering Company, Ltd., Govan, Glasgow, on August 17, 1942, and she slid down the way on December 20, 1945, but she was also stopped in 1946 and she was laid up at Greenock.

With a standard displacement of 9550 tons and a full load displacement of 11,700 tons, all three ships have a length between perpendiculars of 538ft, an overall length of 555ft 6in, a beam of 64ft and a draught of 21ft.

As originally designed, they were to have had a main armament of nine 6in guns in three triple turrets, two forward and one aft, and a secondary battery of ten 4in anti-aircraft guns, together with sixteen smaller A.A. guns and eight 21in torpedo tubes, but this entire armament has been suppressed in favour of only four 6in guns in twin turrets and twelve 3in anti-aircraft weapons in twin mountings, which at first sight appears to be inadequate as compared with her immediate predecessors and foreign contemporaries.

The new pattern 6in guns, however, will have a rate of fire practically three times that of any existing gun of the same calibre now in service, and will deliver some 5 tons of shell on target every minute at a range of 13 miles. The new guns will be directed by the latest fire control equipment which will reach out far beyond the range of the guns themselves and which will be equally effective under both visual and blind conditions. They can be used against both air and surface targets, and by radar, through an electronic brain, the guns will be automatically locked on to any target. The anti-aircraft armament of the "Tiger" class will consist primarily of the new 3in guns which are coming into service, and which have a rate of fire comparable with that of heavy machine guns. And with the reduction in the number of 6in guns from nine to four and the suppression of triple turrets in favour of twin turrets, both grouped forward, and the 3in guns disposed on the beam amidships, there would be plenty of room aft for the mounting of guided missiles, on the lines of the arrangement in the American cruisers converted into guided missile ships.

The Admiralty has announced that the "Tiger" will be completed by John Brown and Co., Ltd., Clydebank, the original builders, and the "Blake" by the Fairfield Shipbuilding and Engineering Company, Ltd., Govan (original builders); but the "Defence" will be completed by Swan, Hunter and Wigham Richardson, Ltd., Wallsend-on-Tyne, with main machinery manufactured by the Wallsend Slipway and Engineering Company, Ltd. But it would appear that these three cruisers are to be not so much resumed from where they were suspended, as dismantled and almost entirely rebuilt, for at the end of the year the ships were being stripped of masts, bridges and superstructure down to the bare upper deck, and it is evident that cruisers of new design will be superimposed on the old hulls. The main propelling machinery comprises four Admiralty three-drum type boilers and four sets of Parsons geared turbines turning four screws and developing an aggregate of 72,500 s.h.p., designed for a maximum speed of 31·5 knots. The vitals of the new cruisers

will be protected by 3in to 4in side armour belts, 2in turrets and 2in decks.

Frigates

Turning from the foregoing big warships outstanding from the 1939-45 emergency war programmes to new units of the post-war naval rearmament programme initiated in 1950, twenty-six frigates were in various stages of construction during the year. These are of four separate types. Six are of the 1st rate of " quality " anti-submarine type named after seaside resorts and known as the " Whitby " class ; twelve are of the 2nd rate or " utility " anti-submarine type named after famous naval captains of the past and known as the " Blackwood " class ; four are of the anti-aircraft type named after big cats and known as the " Leopard " class (another is being built for India), and four are of the aircraft

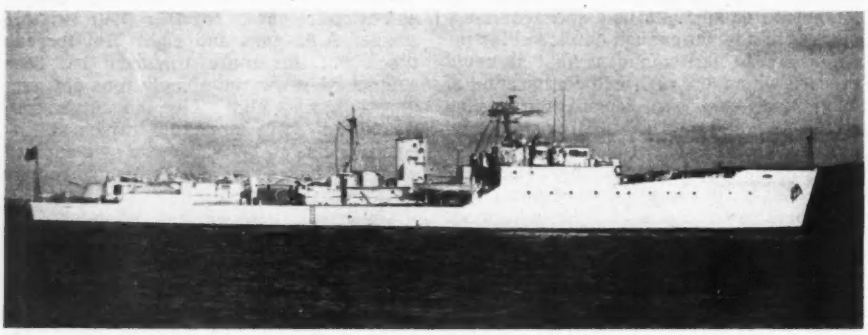


Fig. 2—H.M.S. " Hardy," Britain's first post-war frigate. Commissioned December 15, 1955

direction type named after cathedral cities and known as the " Salisbury " class.

The first two of the new type of six large and fast first rate anti-submarine frigates for the Royal Navy, and the first warships of substantial size in the post-war new construction programme, were almost completed at the end of the year. They are H.M.S. " Torquay," built at the Belfast yard of Harland and Wolff, Ltd., where she was launched on July 1, 1954, and where a sister ship, the " Blackpool " is being built ; and the " Whitby " which came off the stocks on July 2, 1954, at the Birkenhead yard of Cammell Laird and Co., Ltd., where the " Tenby " also took the water on October 4, 1955, these two firms also being responsible for the manufacture of the main machinery. Of the remaining two vessels of this class, which are under construction by Vickers-Armstrongs, Ltd., at its High Walker yard, Newcastle upon Tyne, with propelling machinery made by Vickers-Armstrongs, Ltd., Barrow-in-Furness, the "Scarborough" left the slip on April 4, 1955, and the "Eastbourne" was launched on December 29, 1955. All six ships are scheduled to be completed by the end of 1956. With an estimated displacement of approximately 2000 tons standard and about 2800 tons full load, they have a length of 360ft on the water line and 370ft overall, a beam of 41ft and a draught of 12ft. The main engine plant comprises Babcock boilers and two sets of geared turbines of advanced design turning two shafts and developing 30,000 s.h.p. equal to a speed of 30 knots. The comprehensive armament includes two 4·5in guns, two 44mm anti-aircraft guns, no fewer than twelve 21in torpedo tubes disposed in eight single anti-submarine mountings and two twin mountings and two of the powerful new " Limbo " anti-submarine weapons of post-war development. These limbos are long three-barrelled depth charge mortars each of which can fire with great accuracy a pattern of large projectiles which can be set to explode at a predetermined depth, and the weapons can be trained over a wider arc than previous types of anti-submarine mortars. These first rate frigates are fitted with the latest underwater detection apparatus, and having been primarily designed for the location and destruction of the most modern types of submarines they are provided with specialised equipment of a highly developed new type and steam propulsion of high power to give them the speed required for their hunting role. Good sea-keeping qualities enable these ships to maintain a fair turn of speed in high seas. The vessels are all welded, and the structural arrangements were specially designed to ensure the lightest possible construction. The opportunity was taken in their building to gain experience in welding procedures and methods calculated to facilitate the rapid construction of similar vessels in emergency.

Four more of the smaller, second rate, anti-submarine frigates were launched during the year, and the number of this utility type under construction was brought up to twelve. These were in the hands of five building firms, each responsible for two or three ships. The first anti-submarine frigate of new construction to be completed for the Royal Navy since the end of the second world war, H.M.S. " Hardy," which was launched on November 25, 1953, began her contractors' sea trials in July 1955, from the Scotstoun yard of Yarrow and Co., Ltd., of Glasgow, where the " Keppel " slid down the ways on August 31, 1954, and the " Malcolm " left the slip on October 18, 1955. The second ship of this class to be completed was the " Dundas," which came off the stocks on September 25, 1953 and began her sea trials in August 1955, from the Cowes yard of J. Samuel White and Co., Ltd., Isle of Wight, where the " Grafton " was launched on September 13, 1954, and the " Exmouth " took the water on November 16, 1955. The name-ship, the " Blackwood," was launched on October 4, 1955, at the Woolston yard of John I. Thornycroft and Co., Ltd., Southampton, where the " Duncan " is also in hand. The third ship of the class to be completed was the " Pellew " which began her contractors' trials in August 1955, from the Wallsend-on-Tyne yard of Swan, Hunter and Wigham Richardson, Ltd., which launched her on September 29, 1954, closely followed by her sister ship, the " Russell " on December 10, 1954. The fourth ship to be completed is the " Murray " which came off the stocks on February 22, 1955, and began her sea trials in November from the Govan yard of Alexander Stephen and Sons, Ltd., Glasgow, where the " Palliser " is also under construction. All twelve vessels have an estimated displacement of approximately 1300 tons standard and about 1700 tons full load with a length of 300ft between perpendiculars and 310ft overall, a beam of 33ft and a draught of 10ft. The armament consists of three Mk. 9 Bofors guns, four 21in torpedo tubes in two twin mountings, and two Limbo three-barrelled anti-submarine mortars. The propelling machinery comprises Babcock boilers and a set of geared turbines of advanced design turning one screw and developing 15,000 s.h.p., equal to a speed of 22 knots. The turbines were manufactured by the hull builders in eight of the class ; by the Parsons Marine Steam Turbine Company, Ltd., Wallsend-on-Tyne, in the "Grafton" and " Malcolm " ; and by the Wallsend Slipway and Engineering Company, Ltd., for the " Pellew " and " Russell." The propelling machinery of the " Hardy " and " Keppel " includes turbines of English Electric Company design. All the ships are of comparatively simple construction and were built in prefabricated sections. These new frigates are of somewhat unorthodox appearance. Instead of the traditional clean-swept profile forward from the break in the forecastle deck, they have convex rather than a concave rise from the bridge structure, which comes right out to the sides of the ship, to the bows where there is a bulwark forming a sheltered prow right in the eyes of the ship, and this, nearly approaching the height of the bridge, will serve to protect scientific apparatus as well as personnel against heavy weather.

Two more of the novel anti-aircraft frigates were launched during the year, namely, the " Lynx," from the Clydebank yard of John Brown and Co., Ltd., on January 12, 1955, and the " Leopard," from H.M. Dockyard, Portsmouth, on May 23, 1955. The " Puma," which took the water from the Greenock yard of Scotts' Shipbuilding and Engineering Company, Ltd., on June 30, 1954, is nearing completion, and the " Jaguar " is under construction at the Leven yard of Wm. Denny and Bros., Ltd., Dumbarton. A fifth ship of this class, the " Panther," being built by John Brown and Co., Ltd., Clydebank, and originally intended for the Royal Navy, has been transferred to the Indian Navy. These new diesel-driven frigates were designed primarily for the protection of convoys against aircraft. They will also serve as medium destroyers in offensive operations. They are all-welded and the structural arrangements represent the last word in the development of modern technique. The opportunity has been taken during their building to study the problems associated with rapid construction in emergency or war conditions. With a displacement of 1738 tons standard and 2200 tons full load, they have a length of 330ft between perpendiculars and 340ft overall, a beam of 40ft and a draught of 8ft forward and 10ft aft. They will be armed with four 4·5in guns in two twin turrets of the same kind as those mounted in the " Daring " class destroyers with gunnery control similar to the armament installed in those ships, two 40mm anti-aircraft guns and a "Squid" three-barrelled anti-submarine mortar. Their propelling machinery consists of Admiralty Standard Range I heavy oil engines coupled to the propeller shafting through hydraulic couplings and oil-operated reverse and reduction gearboxes, turning two screws and developing 16,000 b.h.p., equal to a speed of 20 knots. The engines of the " Puma " of the latest Admiralty design, were manufactured by H.M. Dockyard, Chatham, and British Polar Engines, Ltd., Glasgow.

(To be continued)

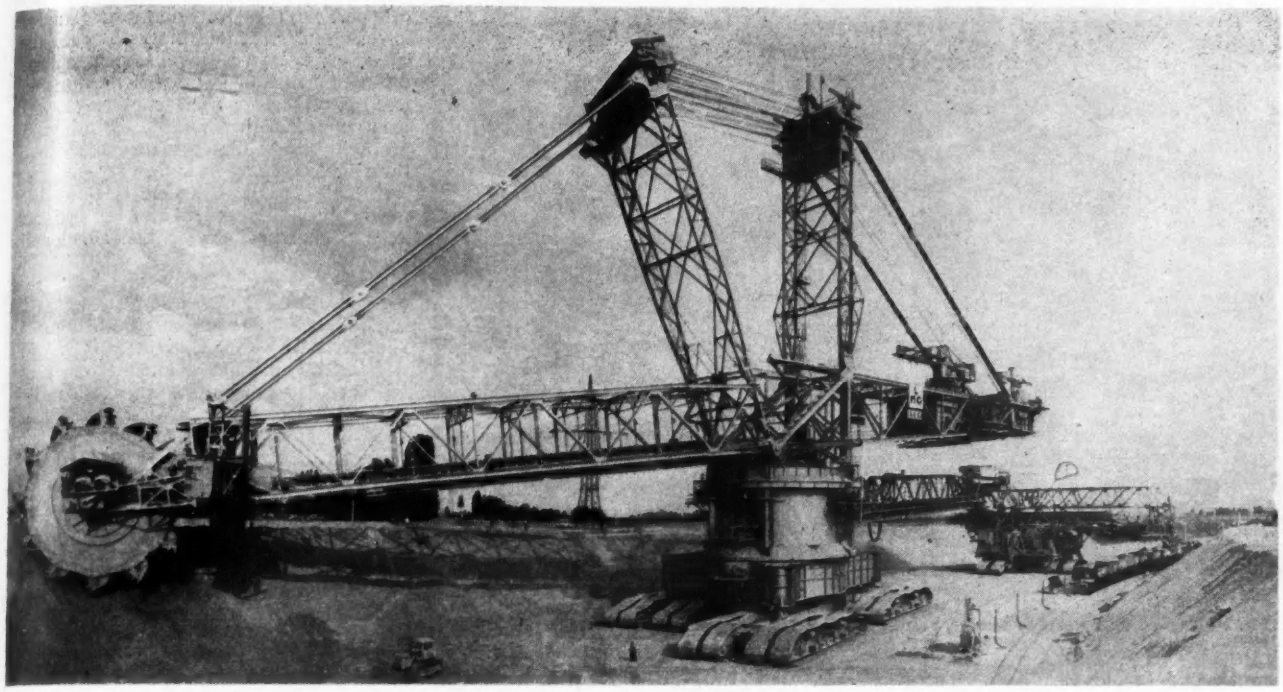


Fig. 1—5600-ton rotary bucket wheel excavator taking its box cut in West German opencast lignite mine

Continental Engineering in 1955

No. I

IN introducing the following brief notes on some of last year's engineering achievements on the European Continent, a few words may be said regarding the background against which these developments took place. Some of the most significant efforts—in view of the general need for greater productivity—were concerned with satisfying the ever-increasing demand for more energy. With atomic power on any scale still many years off, the fullest utilisation of traditional sources of energy is to-day of paramount importance. It now appears that with respect to the most important of these, coal, some perhaps over-sanguine hopes have not so far been fulfilled. Thus, three years ago, the High Authority of the European Coal and Steel Community published provisional estimates, according to which, by 1956–57, coal production was expected to reach an annual 275–285 million metric tons, while crude steel and iron ore production was expected to reach, respectively, 47–50 million tons, and 22–23 million tons (iron content). It now appears that while iron ore and steel are developing as forecast, coal output is substantially below the hoped-for figure. In 1954, for instance, E.C.S.C. production of hard coal amounted to only 242 million tons, slightly below the output achieved in 1938, which has never yet been surpassed. Taking the E.C.S.C. countries as a whole, the reason seems to be that, on the one hand, coal is harder to get, on the other, recruitment of young men for the pits is falling, so that the number of miners grows less while their average age increases. Although in the period 1950 to 1954 increases in employment have occurred in the Ruhr (10 per cent), Dutch Limburg (12·4 per cent), and some other places, due chiefly to the influx of refugees or general population trends, these increases have been more than offset by losses elsewhere, ranging from −2·2 per cent for the Saar to −28·2 per cent for the Centre-Midi coalfields. After a post-war peak of 935,000 men employed in coal mining in 1952, by 1954 the total had dropped to 917,000. Underground output per man-shift is still below the 1938 average of 1590 kg, although it has been steadily increasing for a number of years and reached 1500 kg in February, 1955.

Some Developments in Opencast Mining

It is not surprising, therefore, that much attention is being paid at the present time to making increased use of the available sources of brown coal. One of the world's most important lignite fields is the district extending from near Bonn to the Dutch border, which has reserves estimated at 60,000 million tons, of which 8000 million to 10,000 million tons are above the 250m level. Owing to the approaching exhaustion of near-surface coal the tendency is towards deeper opencast mining, for though underground mining is possible it is both difficult and wasteful because large pillars of coal have to be left standing to support the overburden.

In 1954 this coalfield yielded 75·7 million tons of lignite (compared with a world production of 464 million tons), involving the removal of 60·7 million cubic metres of overburden. It is hoped to increase output to 94,000,000 tons in 1960, necessitating the shifting of 200 million cubic metres. For operations on such a scale some exceedingly heavy machinery is to be employed. Our illustration, Fig. 1, shows the first of a group of very large bucket wheel excavators, which came into service last year in the newly-opened mine "Fortuna." This machine, which is described in more detail on Plate 15 of this issue, is the largest of its kind in the world and weighs 5600 tons. One reason for the decision to use rotary bucket excavators at "Fortuna" is the geology of the coal seam, which lies very unevenly, with a number of faults. The excavator, which is at present taking its box cut down to 50m level, will be able to follow the seams accurately and separate the various grades, which differ considerably in their ash and water content.

The excavated material is removed by railway, and in order to keep the trains reasonably short special wagons of large capacity have been constructed. One of the wagons for the removal of overburden may be seen in Fig. 2. This can be topped in under one minute to 110 cubic metres, or 180 tons, making its total laden weight 240 tons. The design is based on an axle pressure of 30 tons, which is 50 per cent above the normal figure and requires a specially heavy rail section. Maximum height and width are 4m. Running on four two-axle bogies, the wagons can negotiate curves of 80m radius. The coal wagons are on a similar scale, holding 114 cubic metres or 93 tons of coal with an empty weight of only 27 tons. In order to pull the 2000-ton trains on gradients of up to 25–30 per 1000, 129-ton B_0-B_0 electric locomotives are used either singly or in tandem. Supplied at 6kV, 50 cycles, these locomotives, made by A.E.G., are equipped either with converters or with transformers and rectifiers, and are rated at 1900kW, 960V d.c. An 8½W amplidyne field control enables the locomotives to be manœuvred by radio during loading.

Generation and Distribution of Electricity

With the demand for both coal and electricity continually expanding, thermal power generation is tending towards larger and larger units, which have a higher overall efficiency and require a smaller capital outlay per kilowatt. While in Britain 120MW sets are becoming a standard size and a 200MW set is under construction, the first 150MW turbo-generator in Europe, built by Brown Boveri et Cie, came into operation at the beginning of 1955 in the Weisweiler power station near Aachen. This station, besides the 150MW set, has two 100MW sets, and provision exists for further expansion. Its present size of 350MW constitutes about 4·2 per cent of the whole of the

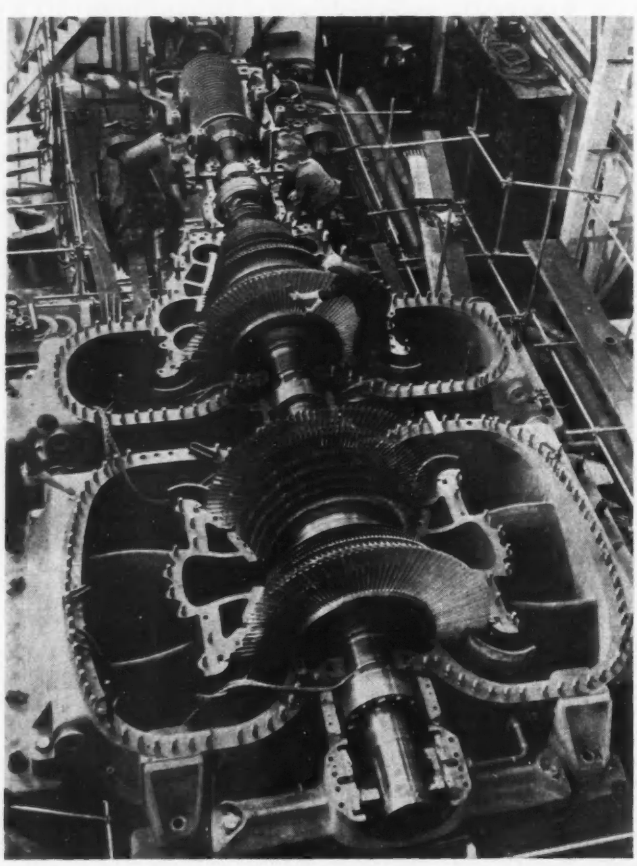
Fig. 2—Wagon for removal of overburden, with a capacity of 110 cubic metres and laden weight of 240 tons

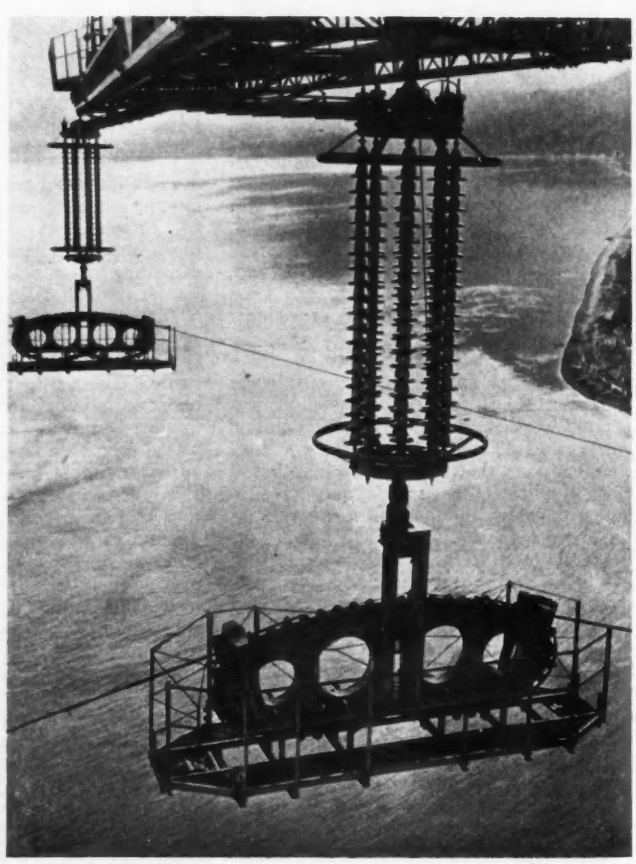
German grid (about 6000MW). The two main factors in its design were the increasing demand—at present growing at the rate of 8 per cent per annum—in the region served by the operating company, the Rheinisch-Westfälische Elektrizitätswerks A.G. (R.W.E.), of Essen. Secondly, the coal used is lignite of high moisture and ash content, with a low calorific value.

The power station is arranged according to the unit system, with two 100-tons-per-hour high-pressure boilers for each of the 100MW sets, and two 300-tons-per-hour forced circulation boilers. Steam conditions are 110 atm, 535 deg. Cent., with feed water heated in six bleed-off stages to 213 deg. Cent. The turbine (Fig. 3) exhausts at 0·055 atm., corresponding to a cooling water temperature of 21 deg. Cent. It comprises three cylinders. The first is a high-pressure cylinder with one impulse and twenty-three reaction stages ; the second cylinder (arranged to be in axial balance with the first) is a combined intermediate and low-pressure cylinder, with twelve intermediate and six low-pressure reaction stages. The third cylinder is also a low-pressure cylinder, arranged in parallel with the previous one, and has two sets of six reaction stages which balance each other axially. Bearings are arranged as follows ; there is a double thrust block and bearing between h.p. and first i.p./l.p. cylinder, a third bearing between the i.p./l.p. and l.p. cylinders, and one bearing between l.p. cylinder and generator.

The h.p. rotor consists of a solid shaft carrying two drums welded together at the rim. The i.p. and l.p. rotors are built up of a number of discs welded together at the rims, without central shaft. Among the measures taken to reduce temperature gradients, the h.p. cylinder was equipped with flange heating, which also heats the bolts. Exhaust steam from the l.p. rotors is guided by ring-shaped vanes inside the volute. The l.p. end vanes are 550mm long and attain tip speeds of 385 metres per second. They are made of 13 per cent chrome steel with hardened leading edges.

The 150MW, 10·5kV generator (Fig. 5) is designed for hydrogen cooling at 2 atm. with a rating of 187·5MVA. The stator housing, which weighs 180 tons without flanges, is of welded construction and, together with the end flanges, was tested to 10 atm. to ensure its resistance to the maximum possible explosion pressure. Dynamo sheets of 0·5mm thickness, with 1·5W-per-kilogramme iron loss, were used. Two symmetrical windings are taken to six terminals each, using flexible connections to obviate the transmission of short circuit forces, with metal foil inserts in the compressed paper lead-throughs to protect the insulation against corona discharges. The





Figs. 3 and 4—(Left) 150MW steam turbine during works assembly. (Right) 220kV crossing of Messina Straits. Two of the conductor supports tested at 50 tons, with eight strings of 20 insulators. The conductor rests on an endless track of arched treads, supported by rollers, of 6 metres radius of curvature

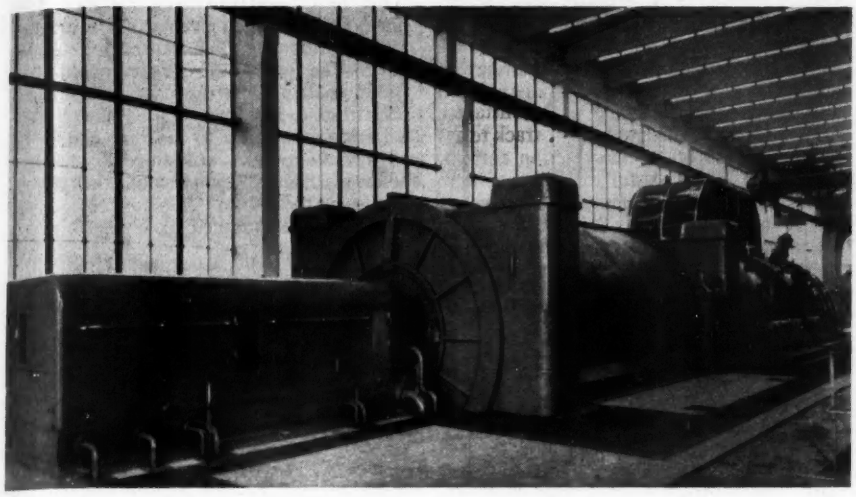


Fig. 5—150MW, 10·5kV, 3000 r.p.m. generator with hydrogen cooling at 2 atmospheres pressure. The 530kW exciter (on left) is directly coupled

cooling coils are placed inside the end flanges and can be lifted out by crane for cleaning. The rotor has a diameter of 1100mm and its windings are directly cooled by the gas. Sealing is achieved by applying oil, at about 0·3 atm. above the hydrogen pressure, to a non-rotating sealing ring. The slip-rings are on the far side of the end bearing, which (like the other bearing of the rotor) is independent of the stator. A new departure is the exciter for 530kW, 1660A, and short peak voltages of 450V, which is directly driven and coupled to the rotor shaft by a gear coupling. In order to stabilise the excitation, an auxiliary exciter is mounted at the end of the shaft. Both sliprings and exciter machines are shrouded by a single housing in which the cooling air circulates. This is equipped with water cooling and a filter for removing dust coming off the brushes.

Plans for supplying main land electricity to Sicily go back to 1921. At first it was intended to drive a tunnel under the straits, but in view of the considerable depth at which this would have had to be bored and particularly the seismic character of the region, the project was abandoned. Later in the same year a proposal was made to transmit 50MW by means of two three-phase circuits, each of six conductors being carried by two towers 277m in height, one on the Sicilian and the other on the Calabrian coast. Researches were also carried out regarding the possibility of a submarine cable, but with unfavourable results.

The matter was again taken up in 1946 by the Compagnia Nazionale Imprese Elettriche (Coniel) and a project called " Coniel D " was evolved for the overhead crossing of the straits between Torre Cavallo and Punta Sottile. A joint undertaking was formed in 1948 by Coniel and the Sicilian Electricity Board (S.G.E.S.), for the construction of the actual crossing and a power line from Faroleto to the Plain of Caporafi to link up with the Sila power stations. The Società Anonima Elettrificazione (S.A.E.), of Milan, undertook the design and began constructional work on January 27, 1952.

Although the straits are narrowest between Cannitello and Ganzirri, the present route was adopted because the rocky nature of the Calabrian coast at this point allows one of the towers to be placed with its foundations at 166·4m above sea level, while the other tower is only 10·2m above sea level (Fig. 6). The main span of 3653m reaches to within 70m of the water at its lowest point. It is at present the longest single span in the world. In addition, there are side spans of 752m in Sicily and 646m in Calabria.

Each of the two identical towers stands 224m high and weighs 500 tons. It is in the shape of a pyramid with a cross-arm 75m long supporting four conductors at a height of 196m (Fig. 6). A second cross-arm, 50m long, has been fitted at the top of the tower and will later carry two conductors at a height of 217·7m. All conductors are mutually spaced 25m apart. Measuring 27·8mm in diameter, they consist of a section of 311 square millimetres of steel and 44 square millimetres of aluminium, and weigh 2·8kg per metre.

Tests were carried out on a 1 : 25 model of a tower to determine its resistance to wind and earthquake. Besides testing the model section by section in a wind tunnel, static and dynamic tests of the 9m high model were undertaken, such as placing it on an oscillating platform to simulate earthquake conditions. The actual towers are designed to resist storms of 150km per hour and earthquakes of 10 deg. Mercalli.

For the foundation on the Sicilian coast, where borings revealed sand to a depth of at least 233m below sea level, a cross-shaped concrete block, 4300 cubic metres in volume, was used, requiring 490 tons of reinforcement. Four 20m piles were driven, one at each footing of the tower. A similar but less massive foundation, without piles, was used on the Calabrian side.

In the first stage about 50MW is being transmitted at 150kV in a single three-phase circuit, while later 150MW will be transmitted at 220kV (or 300MW if two circuits are installed). The conductors are anchored on the Calabrian side and counterweighted on the opposite coast. As opposed to having fixed conductors, this method gives constant tension under all conditions of temperature and external loading. In consequence, a higher tension can be applied initially and the sag reduced.

Where a temporary demand for electricity cannot be supplied from the grid, as may be the case with large construction or mining projects in distant parts of the world, or where drought or natural catastrophes have interrupted normal supplies, mobile power stations provide the answer. For these the gas turbine has certain advantages because of its high power/weight (or power/volume) ratio. Two mobile units of 6·2MW capacity were delivered last year to Mexico by Brown Boveri et Cie, of Baden (Switzerland).

Each of these installations consists of two carriages and has an overall length of 42m. With a total weight of 236 tons, the output corresponds to 38kg per kilowatt. Our illustration, Fig. 7, shows the turbo-set on the left. The other carriage contains the main and service transformers, switches, starting battery and auxiliary air cooled diesel generator-compressor set. Power is generated at 6·6kV, 60 c/s, and can be transformed to voltages varying between 2·4kV and 13·8kV. The turbine operates at 650 deg. Cent. and with an air inlet temperature of 20 deg. Cent., thermal efficiency of generation is stated to be 19·1 per cent. The turbine uses bunker fuel, or diesel oil for starting. Measuring 23m in length (without buffers), the set weighs 158 tons, including fuel. For the transformer carriage the corresponding figures are 19m and 78 tons. The design of the generating plant resembles that of the B.B.C. gas turbine locomotive, but the various machines are mounted directly on the carriage chassis built by Schweizerische Lokomotiv und Maschinenfabrik, Winterthur. While weight had to be kept as low as possible, the maximum permissible deflection of the chassis was limited to 0·5mm over the combined length of turbine and compressor (6·3m), in order to prevent interference of the vanes. The frame accordingly consists of two longitudinal " I "-beams of 15·5m span and 2·2m maximum depth. During operation the unit rests on the rails on screw jacks. To save space the air duct from the compressor to the combustion chamber surrounds the duct from the chamber to the turbine. The whole installation is operated by three men and, starting from cold,

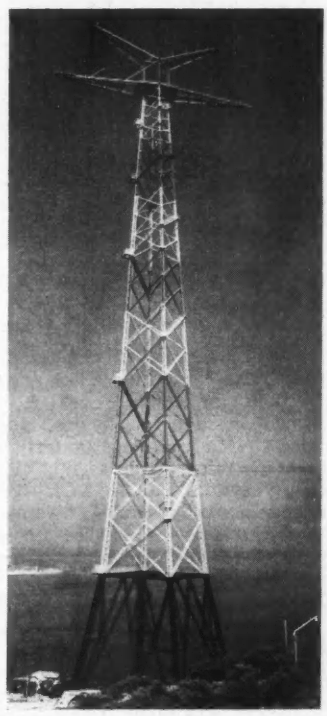


Fig. 6—220kV crossing of Messina Straits with a main span 3653m long

is claimed to reach full power in fifteen to twenty minutes.

Some Railway Developments

After electrifying in previous years 2800 miles of line—in particular the main lines Paris–Lyon, Paris–Hendaye, Paris–Toulouse and Nîmes, and Paris–Le Mans, which carry

30 per cent of the total traffic, the French Railways continued last year to electrify the northern and eastern portions of the network. However, unlike previous electrifications which were based on 750V or 1500V d.c., the new lines were to be at 25kV, single phase, 50 c/s. Substantial economies on high-tension lines, substation equipment and contact wires were thus made possible. Trials carried out since 1950 in the Annecy region had demonstrated the success of the system. At the same time locomotives had to be designed capable of hauling freight trains of nearly 2000 tons on gradients many of which continue for long stretches at 1 in 100. Following the opening of the section Valenciennes–Charleville in 1954, the remaining line to Thionville was opened on June 29th of last year. Further extensions will electrify the sections Valenciennes–Lille and Thionville–Metz–Sarrebourg–Strasbourg–Basle. Later, the Paris–Nord network will be electrified, of which Paris–Lille is the most important artery.

In the Valenciennes–Thionville electrification, the same techniques were employed as on the Paris–Lyon line. These included special trains for concrete mixing, cable laying, and erection of pylons, and of catenaries. A daily average of forty work trains was operated, rising to fifty at peak periods. The track had to be lowered in eleven tunnels, totalling over 4300 yards, and seventy-two bridges had to be raised or reconstructed to give the necessary clearance for the catenary ; 725 miles of contact wire and 20,320 catenary supports were erected, and some 67 miles of automatic block signalling was installed.

The choice of a 25kV feed made it possible to use simple transformer substations of standard design, spaced up to 46 miles apart. These could in some cases be housed in existing substations of the 150kV grid which follows the railway closely. Less than 6 miles of new high-voltage lines to substations were required.

The catenary is in the form of a 65 square millimetre bronze wire supporting a grooved copper contact wire of 107 square millimetre cross section. On secondary lines, the bronze wire is replaced by steel. Supports consist of light galvanised steel girders, with simultaneous tensioning of catenary and contact wire where necessary. Automatic block signalling operates on current of 83⅓ c/s (with a few exceptions where direct current can be used) for which special distribution cables and substations had to be installed. The use of this frequency prevents track relays from being tripped by the traction current. More recently, successful experiments were conducted with current of industrial frequency feeding track circuits in conjunction with electronic equipment, a system which will probably be used extensively in future 50-cycle traction.

Four different types of locomotive were decided upon for the Valenciennes–Thionville line. Orders were placed for sixty-five " CC " locomotives with single-phase/d.c. generator sets ; twenty " CC " locomotives with single-phase/three-phase rotary converters ; fifteen " BB " locomotives with single-phase commutator motors, and five " BB " locomotives with ignitron rectifiers. The " CC " locomotives are intended for freight trains, which constitute the main part of the traffic. They can be used regeneratively on down grades. Adhesion in excess of 35 per cent has been obtained during tests.

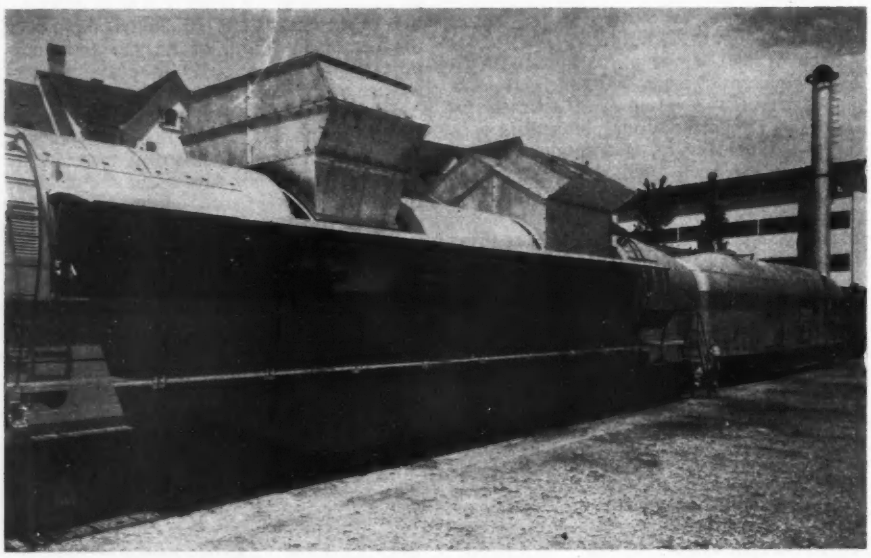


Fig. 7—6·2MW mobile gas-turbine generator set. Power generated at 6·6kV, 60 cycles, can be transformed to 2·4—13·8kV

On March 28 and 29, 1955, high-speed trials were conducted on the line Lamothe–Morcenx involving d.c. locomotives " CC–7107 " and " BB–9004." Each locomotive achieved a speed of 331km per hour, while pulling a three-coach train of 111 tons. These results followed tests carried out on February 21, 1954, in which locomotive " CC–7121 " (built by Société Alsthom) reached 243km per hour on the Dijon–Beaune section of the line Paris–Lyon.

The 66km section Lamothe–Morcenx, on the line Bordeaux–Dax was chosen because it carries the longest straight track in France, with a single curve of 3120m radius at Labouheyre, 47km from Lamothe. Although the sea level of Morcenx is 66·77m above that of Lamothe, the test runs were nevertheless made against the gradient for reasons of safety, as the speed limit at Lamothe is 110km per hour compared with 220km per hour at Labouheyre.

Before the test, locomotive " CC–7107 " had done 448,000km in the south-west, and " BB–9004," 160,000km on the Paris–Lyon line. They had been given a general overhaul and the following modifications were carried out :—The gear ratios were raised from 0·384 to 0·873 on the " CC " locomotive, and from 0·398 to 1·175 on the " BB " ; a fairing was added to the rear end of the engines to connect with the first carriage's bellows, which totally enshrouded the circumference ; the motor shunts were modified and auxiliaries adapted to a higher supply voltage ; safety grilles were fitted in front of the windscreen, and measuring apparatus was installed. Since in previous tests arc formation had occurred at the wheels, the current return was distributed over the axles of the locomotive and the first two carriages.

A more detailed description of the two locomotives will be found in our article of April 8, 1955 (page 484). The trains consisted of carriages built in 1946 fitted with heavier welded bogies of 1950 design, with monobloc wheels and double brake shoes. By using monobloc wheels, a dissipation of 70kW per wheel could be achieved. A special streamlined fairing was used at the rear end of the last carriage, and enshrouding bellows were fitted between carriages. As many projecting parts as possible were removed in order to reduce the air resistance. Wind tunnel tests on 1 : 20 models of the trains used in the tests of February, 1954, had shown that streamlining might be expected to reduce the drag from 0·06kg to 0·039kg sec^2/m^2, but to give a margin for error calculations were based on a figure of 0·045.

During the test runs a maximum of 8200kW was absorbed by " CC-7107," involving a power supply at the substations of 11,800kW. For the " BB-9004 " locomotive these figures were 9400kW and 12,250kW. Such values could only be achieved by reinforcing the substation at Licavgas (3000kW), 23·5km from Lamothe, by three mobile rectifier substations at Lamothe (2000kW), Lugos (4000kW) and d'Ychoux (4000kW), the voltage to these substations having been increased by means of an autotransformer from 60kV to 75kV. In addition, there were the existing fixed substations at Lamothe (3000kW), Labouheyre (2000kW) and Morcenx (3000kW). Tension at the pantograph varied between 1500V and 1900V.

In order to obtain the very heavy currents of 4000A, normally reached only during starting, special consideration had to be given to the pantographs, bearing in mind the fact that the catenary was comparatively light and non-compensated. The design eventually adopted had double contactor strips, and its stability had been tested in the Modane wind tunnel at 410km per hour. Dangerous oscillations of the catenary precluded the use of two pantographs above 120km per hour. During the test runs the pantographs were kept under constant observation through periscopes. At the maximum speed attained they had to be lowered owing to the contactors having burned away. The test runs are stated to have been singularly smooth, and no major wear or damage was found on subsequent examination of the locomotives and trains, other than at the pantographs.

Like its record-breaking predecessor, the locomotive " CC-7107 " was built by Société Alsthom. The other locomotive, " BB-9004," was a prototype, constructed by Le Matériel de Traction Electrique, an association of Société des Forges et Ateliers du Creusot, Forges et Ateliers de Constructions Electriques de Jeumont, and Le Matériel Electrique S.W.

(To be continued)

Industrial and Labour Notes

Iron and Steel

At the beginning of this week the British Iron and Steel Federation issued an appraisal of the steel situation, wherein it is stated that Britain's steel production in 1955 is estimated to have totalled nearly 19,800,000 tons, an increase of more than 1,250,000 tons on 1954. It is hoped that this year steel output may increase by a further 6 per cent, bringing the annual production to 21,000,000 tons. In 1955 the total supply of steel in this country was 21,700,000 ingot tons, of which imports contributed 8½ per cent. This total, it is stated, was 2,200,000 tons more than in 1954. Steel supplies to British industry were increased by 1,800,000 ingot tons and exports by 400,000 tons.

The Federation points out that, in the ten years since the end of the war, steel output has been increased by two-thirds. A substantial proportion of the existing capacity is now completely new and much of the remainder has been modernised. During this ten-year period the British steel industry has spent on average £1,000,000 a week on modernisation and development. Pig iron output per furnace is now 75 per cent higher than it was ten years ago, and steel output per open-hearth furnace is also 75 per cent higher. New and modernised plants naturally help the industry to use raw materials with ever-increasing efficiency and economy. Fuel consumption per ton of steel produced, for example, has been cut by about 15 per cent since the end of the war.

Engineering Wages

On Thursday of last week there was a meeting between representatives of the Engineering and Allied Employers National Federation and the Confederation of Shipbuilding and Engineering Unions for a preliminary discussion of the wage claim submitted recently on behalf of engineering workers. The claim, which was formally handed in by the union representatives on November 3rd, mentioned a "substantial increase," but did not specify any particular figure.

At last week's meeting the representatives of the employers pointed out the difficulty of replying to the rather vague demand which the unions had put forward, and they asked for a definite figure. The meeting was therefore adjourned in order that the spokesmen for the Confederation of Shipbuilding and Engineering Unions might consider the matter. Later it was stated that a claim had been made for a 15 per cent wage increase. Since March of last year, when the last increase was agreed, the minimum weekly rate for skilled men in the engineering industry has been £7 15s. 10d., and for unskilled men £6 12s. 10d. The Engineering and Allied Employers' National Federation is now seeking the views of its member firms on the claim. It has promised to give its reply to the unions on February 2nd.

Changes in Wage Rates

The Ministry of Labour has reported that in the first eleven months of last year the changes in wage rates which came into effect in the United Kingdom resulted in an aggregate increase of £4,857,800 in the weekly full-time wages of 11,537,000 workpeople. In the corresponding period of 1954 there was a net increase of £3,375,000 in the weekly full-time wages of 9,940,000 workpeople.

The changes which became effective in November last led to an aggregate increase of about £148,000 in the weekly full-time wages of 508,000 workpeople. Among those who received wage increases were workers in the iron and steel industry, certain engineering and motor transport grades employed in the Post Office, and bus drivers, conductors and maintenance staff employed by company-owned motor omnibus undertakings and by London Transport. At the end of November the index of rates of wages (June 30, 1947=100) stood at 154 for all workers. A year earlier the index number for all workers was 144.

Industrial Disputes

There were 235 stoppages of work through industrial disputes in the United Kingdom reported to the Ministry of Labour as beginning in November last. In addition, there were twenty-eight disputes, which had started earlier, still in progress at the beginning of that month.

The Ministry of Labour says that as a result of these 263 stoppages about 48,400 workpeople were involved directly and indirectly in November and that 288,000 working days were consequently lost. The stoppages included 174 in the coal mining industry, involving 21,600 workers and causing a loss of 40,000 working days. In the shipbuilding and ship repairing industries there were twenty-two stoppages of work in progress in November. They involved 4400 workpeople and led to a loss of 34,000 working days.

In the first eleven completed months of last year 2280 stoppages of work through disputes were reported to the Ministry of Labour. There were about 651,600 workers involved in them and the number of working days lost is estimated as 3,674,000. In the comparable months of 1954 the number of stoppages reported was 1867, the number of workpeople involved being 417,900, with an aggregate loss of 2,376,000 working days.

Middle East Market Survey

The British Internal Combustion Engine Manufacturers' Association says that its director, Mr. Malcolm Logan, is visiting the Middle East to carry out market surveys in Iraq and Iran. He is to examine future sales possibilities in these countries for stationary diesel and petrol engines and for engines in the locomotive and marine spheres.

The Association states that available figures for direct exports from the United Kingdom of marine and stationary engines and parts suggest that business in 1955 may show some decline in Iraq and an improvement in Iran, compared with 1954. During the first nine months of last year exports to Iraq, which totalled £455,958, were down by 13·9 per cent on the same period in 1954. The comparable figure for Iran was £426,456, an improvement of 33·9 per cent.

Growth of British Industry

It is stated in the *Board of Trade Journal* that preliminary estimates of the results of the Census of Production for 1954 indicate that the value of the output of manufacturing industry in the United Kingdom was about 15 per cent greater than in 1951. About 12 per cent of the increase was achieved by a greater volume of production and 3 per cent is accounted for by higher prices. The Board of Trade says that in the period 1951–1954 employment increased by under 3 per cent. The expansion of output, it is pointed out, has been associated with substantial capital investment since the war, a trend which continued throughout 1954, when the total capital expenditure in manufacturing industry was nearly 10 per cent more than in 1951. Wages and salaries increased more rapidly than the value of output, being 26 per cent more in total in 1954 than in 1951.

The Board of Trade explains that its conclusions have been based on the census returns so far received, which relate to about 70 per cent of all the larger establishments within the census field, as measured either by the number of establishments or by the numbers employed. It is also recalled by the figures that progress between 1951 and 1954 was not continuous. There was a sharp drop in industrial production in 1952, and the recovery in 1953 brought the level of output only slightly above the 1951 figure, the production index showing an increase of 2 per cent for manufacturing industry between the two years. The improvement shown in 1954 compared with three years earlier was for the most part, therefore, the result of vigorous growth in that year, a growth which, as shown by the index of production, continued into 1955.

It is noted in the Board of Trade's analysis that the metals, engineering and vehicles industries, and the manufacture of chemicals continued to show rapid expansion between 1951 and 1954. Although price played a part in the increase in gross output in these industries, it was, in general, the Board comments, "less important than the increase in the volume of production." Another comment made is that, in vehicles and engineering, large increases in output have been achieved with an overall level of capital investment which is not so high in relation to their size as in many other industries.

Apprentice Training in Western Germany

The Birmingham Productivity Association has recently published a report, entitled *Gaining Skill*, concerning an investigation into the training of industrial apprentices in Western Germany. The Association sponsored the sending of a team of experts, some months ago, to Germany under the leadership of Mr. J. Wilson, principal of the Birmingham College of Technology. This team was representative of education, management and trade unions, and the report now published sets out its main findings. In the report there are included descriptions of German systems of apprentice training, the schemes of study and practical instruction, and the methods by which these are organised and administered.

The introduction to the report emphasises that, from the outset, the members of the team clearly understood that there existed in Germany conditions which differed materially from those in England, such as climate of opinion, native temperament and traditional methods. Consequently, it was considered desirable neither to make comparisons between apprenticeship systems in the two countries nor to make recommendations for the adoption of a scheme of education and training of craft apprentices in this country based, in whole or in part, on the German pattern. Furthermore, the report says, the members of the team were well aware of the many excellent schemes of training operated by individual firms in the United Kingdom. Nevertheless, they recognised the need for a greater adoption of systematic and improved training of craftsmen if British industry was to have personnel available in sufficient numbers and of the right quality to maintain Britain's position in the face of increasing competition for world markets.

The report, which costs 7s. 6d., can be obtained from the Birmingham Productivity Association, 95, New Street, Birmingham, 2.

International Productivity Essay Competition

The British Productivity Council is co-operating with the European Productivity Agency in the promotion of an "international productivity" essay prize competition. The aim is to encourage young people to look for and study methods of increasing productivity.

The competition is limited to students who are now attending a course of study in industrial or technical subjects (including economics and agriculture) endorsed by a recognised educational body. Entrants for the competition must be under twenty-seven at December 31, 1955. The essays, which should be not more than 4000 words in length, should describe how a significant increase in productivity has been achieved in some specific plant, firm or organisation through the introduction of new methods or the use of special techniques. The judges will take into account not only accuracy of description but also constructive thought shown by the writer.

Entry forms for and full details of the competition may be obtained from the British Productivity Council, 21, Tothill Street, London, S.W.1. The closing date is March 7th.

Power from Niagara Falls

BY OUR AMERICAN EDITOR

Whatever his other qualifications for high office, W. Averell Harriman, the Governor of New York State seems to have mastered one of the primary arts of politics—always tell an audience what it wants to hear. In October, to a group of Midwestern farmers, he figuratively held out a federal horn of plenty, including a return to high and rigid price supports and Federal subsidies for perishables. In November, when the harassed Long Island Railroad raised its fares, the former chairman of the flourishing Union Pacific Railroad indignantly vowed a speedy investigation. But it was in Oregon recently, in an attack on the Eisenhower Administration's power policies, that Mr. Harriman rose to the peak of his forensic form. The Republican Party, said he, dominated as it is by "Eastern business interests," has set out to strangle the growth of the West. "And we in New York," he went on, "need your help, too, to prevent the gigantic 'give-away' Republicans are pushing at Niagara Falls." As the election year 1956 begins, these statements are noteworthy in several respects, not least for the fact that they come from a man who, while admittedly available, continues to disclaim any active part in seeking the Presidency. They also suggest that Mr. Harriman, when he urged his party to abandon all counsels of moderation, was in dead earnest. But beyond any other considerations, his remarks focus attention on the controversy currently raging in New York State between the forces of public and private power. This dispute, as it happens, cuts sharply across the customary political and economic lines, stamping the Governor's charges as inappropriate. Nonetheless, a great deal is at stake at Niagara and, to a lesser extent, along the St. Lawrence. For the schemes advanced by both Democrat Harriman and his Republican predecessor, Thomas E. Dewey, are part and parcel of the long effort to usurp the part played by private capital in the generation of electricity. They represent, in the opinion of many Americans, socialised power production.

While its voltage has been stepped up rapidly of late, the power dispute in New York State dates back to 1950, when the United States and Canada revised a long-standing treaty governing the flow of the Niagara River. Both countries agreed that without impairing the scenic beauty of the Falls, a much larger volume of water could be diverted to the production of electricity. The decision was a momentous one for the entire Niagara Frontier and particularly for the region's utility industry, which, since the start of the century, had been using part of the mighty current to turn its turbines. Almost at once a group headed by the Niagara Mohawk Power Corporation proposed the construction of a 1000MW installation at Niagara, designed to cost some 400 million dollars. However, while the usefulness and desirability of such a project have never been challenged by anyone—indeed, across the border the Canadians have built similar facilities on an equally grand scale—not a spadeful of earth has been turned on the American side of the stream. The damage as is so frequently the case, was done in Congress, which under the treaty has the final say on any new Niagara project. Nearly three years ago a bill was introduced giving the private utilities the right to proceed with construction. While this measure, the so-called Capehart-Martin-Miller bill, passed the House by a sweeping majority, the Senate failed to act. Meanwhile, other claimants appeared on the scene. The advocates of public power urged that the site be reserved to the Federal Government. The State of New York, at the behest of then-Governor Dewey, also took a hand in the matter. The Niagara, he argued, should be developed only by New York, acting through its established State Power Authority, a stand which since has been embraced by his Democratic successor. And there, in complete discord, the matter rests, while the Niagara, largely unharnessed, pursues its majestic course.

Mr. Dewey, it appears from the record, was concerned mainly about aquiring for New York State the same kind of tax advantages enjoyed by others; in his opinion this had nothing to do with socialism, which he never failed to denounce. Be that as it may, the New York State Power Authority, and particularly its present superiors in Albany, evidently have no such scruples. For the Authority, while nominally still Republican-dominated, of late has been showing its leanings ever more plainly in a matter distinct from, but obviously linked to, the Niagara scheme. Specifically, it has been talking about building transmission lines from its big development now building on the St. Lawrence. The statute under which the Authority operates seems clear on the point—wherever possible, transmission lines should be contracted for or leased from private industry, not built with public funds. Nevertheless, in what looks like a move to coerce the same private utilities as are also involved at Niagara, the Authority has been threatening to go ahead on its own. In this effort it has demonstrated a striking contempt for both the common weal and for public opinion. On the first count, it is obvious that the citizens of New York, on the slimmest of pretexts, have been deprived for five years of the benefits of relatively cheap, efficient hydro-electric power; some of this harm, moreover, owing to the rise in construction costs, is probably beyond repair. As an important presidential election is approaching this year, such important aspects of the issue of public versus private power development at Niagara Falls are expected to furnish a major source of political ammunition, at least in New York State. Thus, one can only hope that, depending on the outcome of the elections this autumn, a decision will be made one way or another so that the American use of hydro-electric power from Niagara Falls will not continue to be thwarted forever.

American Water Power Schemes in 1955

PROGRESS of civil engineering construction during the past year was again influenced much by political developments in the field of power generation, and as the first four-year term of the Republican Administration of President Eisenhower draws to a close it seems appropriate to review the effects of what has commonly become known as a "partnership" between the Federal Government and local interests in the development of potential hydro-electric resources. Since the national election campaign of 1952, the subject, which had been a somewhat dormant political issue, has become one for extended public debate. Significantly the political cleavage is not at all definite, for members of each party have been equally vehement in support of, and attack on, the partnership concept. In the public debate that has ensued, many explanations of the partnership plan have been given, many questions asked, many assertions made that it is unworkable, and many other assertions made that it is entirely practical.

The partnership plan is not a new idea. It has been used for almost fifty years and during that time has not been the exclusive property of any political party. As early as 1908 the Bureau of Reclamation built three small hydro-electric plants in connection with an irrigation project in the Strawberry Valley in Utah. Under an agreement with the Bureau, these plants are

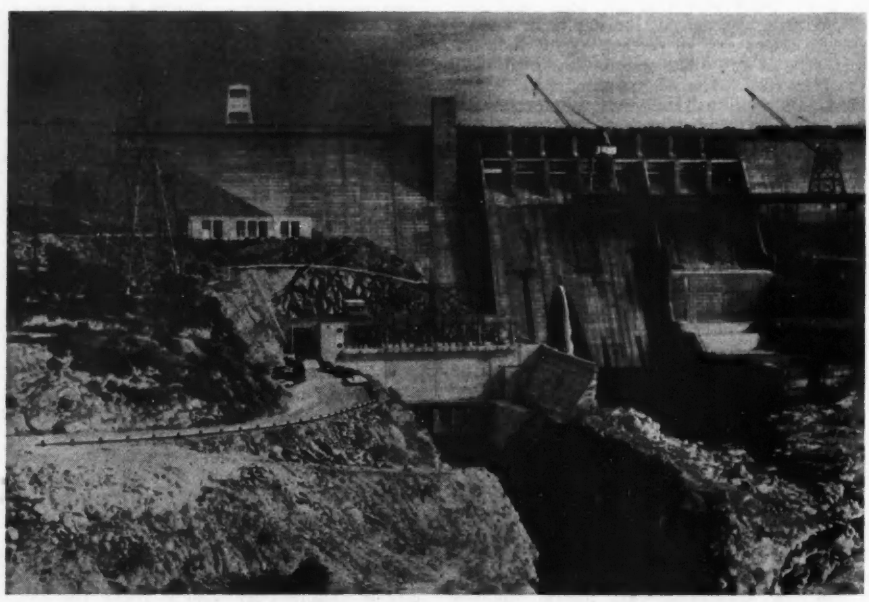


Fig. 1—1400ft long main concrete section of Folsom dam viewed from downstream side

operated by the local water users. This general plan was repeated in 1909 at the Roosevelt dam in Arizona, in 1911 on the Newlands project in Nevada, in 1916 on the Yakima project in Washington, and in 1932 on the Grand Valley project in Colorado. In 1946 the Bureau of Reclamation made a comparable arrangement with the Pacific Power and Light Company at the Cove plant on the Deschutes River in Oregon. Altogether, by 1953, there were at least twenty-six examples of partnership in power production between the Federal Government and local interests. Thus, President Eisenhower felt that the principle had been tested and found entirely workable. A number of new partnership proposals were initiated after the Eisenhower Administration took office. Some of these now have been adopted while others are pending.

An interesting scheme that has been approved by Congress and President Eisenhower is the Markham Ferry dam and reservoir on the Grand River in Oklahoma. This was strongly supported by local interests and Senator Kerr was the driving force that successfully obtained Congressional endorsement. Actually, the Markham Ferry project goes back several years to 1937, when the Grand River Dam Authority, a state agency, started the construction of the Pensacola dam and reservoir on the Grand River. This combined flood control and power project cost 27,000,000 dollars, of which 60 per cent was loaned and 40 per cent granted to the Authority by the Federal Public Works Administration. Under a Federal Power Commission licence the Authority installed 90MW of generating capacity. This was in itself a partnership arrangement. The entire project was owned and operated by a local body and was made possible in this instance by funds loaned and granted by the Federal Government. In 1938 a general plan of federal development of flood control reservoirs on the Grand River was authorised by Congress. In 1941 Congress specified that this plan should include the existing Pensacola dam and new projects at Markham Ferry and Fort Gibson, all to be operated as a co-ordinated unit in the interest of flood control and power development. Subsequently, the second in this series of dams—the Fort Gibson dam and reservoir—was built and is now operated by the U.S. Army Corps of Engineers.

In the case of the third dam, Markham Ferry, it appeared that for fiscal reasons it might well be a long time before the Federal Government could undertake its construction. Therefore, a partnership proposal was made by the local interests to the Eighty-first Congress and again to the Eighty-second Congress, but without success. The legislation was finally passed by the Eighty-third Congress and approved by President Eisenhower on July 6, 1954. The Markham Ferry dam and reservoir will be built, owned and operated by the Grand River Dam Authority of Oklahoma. The Federal Government will contribute to the Authority an amount not to exceed 6,500,000 dollars to pay for the flood control aspects of the project. The flood control operation will be in accordance with rules established by the U.S. Army Corps of Engineers and to ensure co-ordinated operation of the other two dams. The remaining cost of the project, estimated at about 32,000,000 dollars, will be provided by the Authority from the sale of revenue bonds secured by power revenues from this and other facilities of the Authority. Thus there is here a partnership involving the co-ordinated operation of three dams built in the interests of flood control and power generation, with one dam built, owned and operated by local interests using loaned and granted federal funds; a second dam built, owned and operated by the Federal Government, and a third dam to be built, owned and operated by local interests with funds partially supplied by the Federal Government and the remainder by the local interests.

Another representative power partnership plan authorised by the Eighty-third Congress was that for a development on the Coosa River in Alabama and Georgia, which was approved by President Eisenhower on June 24, 1954. In 1945 there had been a federal authorisation for building a series of navigation, flood control and power dams on this river at an estimated federal cost of 60,000,000 dollars. No construction funds were appropriated and no work accomplished. In 1954 all members except one of the Alabama Congressional delegation and the Governor of the State joined in supporting new legislation for the development. This legislation authorises the development by a local interest, which will be the Alabama Power Company. The company has proposed to spend 100 million dollars to build the dams required and to install initially 240MW with an ultimate goal of 360MW. The legislation requires that basic provisions be made for the future construction of navigation facilities. It also requires that provisions for flood control be made as may be found economically feasible in the judgment of the Army Corps of Engineers. Unlike the Markham Ferry scheme, where a federal grant was made for flood control costs, there is no grant at this time for these costs on the Coosa River. There is only a provision that if at some future time Congress adopts a general policy of compensating local interests for flood control and navigation costs, such general authorisation will be applicable. The legislation provides ample safeguards to ensure a development by the local interests that will be no less effective than one carried out according to the federal plan. This project is thus an example of partnership where the Federal Government has authorised the local development of a scheme that had earlier been planned and authorised for federal handling.

At Priest Rapids on the Columbia River in Washington, another partnership plan has now been authorised. This is in many ways comparable to the Coosa River plan, except that at Priest Rapids a local public body is the partner while on the Coosa the local interest is a privately owned "utility." Here, too, the project was earlier approved by Congress for federal development. It is a large scheme which was estimated in 1950 to cost 364,000,000 dollars, of which 65,000,000 dollars would be for flood control, 10,000,000 dollars for navigation, and 289,000,000 dollars for power production. In this instance the legislation, which was passed by the Eighty-third Congress and approved by President Eisenhower in 1954, authorises a local public utility district to develop the project. Its plan must be approved and a licence issued by the Federal Power Commission to ensure the optimum development of the resource.

One of the most interesting of the partnership proposals still being debated in Congress is a proposal by local interests to share in the cost of the John Day dam on the lower Columbia River, where it forms the boundary between the states of Oregon and Washington. This is a navigation and power generation scheme, estimated by the Army Corps of Engineers to cost 310 million dollars, of which approximately 273 million dollars would be allocated to power production. A group of local utilities have proposed that they advance to the Federal Government the full cost of the power production allocation and that in return they receive the power from the project for a period of fifty years, less any power needed to operate the dam and its locks. In effect these utilities would pay in advance for their power, and this advance payment would be used to pay for construction. The ownership and operation of the dam would remain with the Federal Government, and the federal contribution would be about 37,000,000 dollars.

The legislation under consideration is such that any local utility wishing to do so may participate in the proposal, and if there are more applicants for power than there is power available an allocation is to be made by the Federal Power Commission. It also provides that the local utilities must pay their proportionate share of the costs of operation and maintenance of the power facilities and portions of the joint project costs allocated to power production. This plan has the merit of providing the navigation facilities which are badly needed now, and the power which the Pacific Northwest will surely need in a few years, without the delay that is inherent in waiting for large federal appropriations.

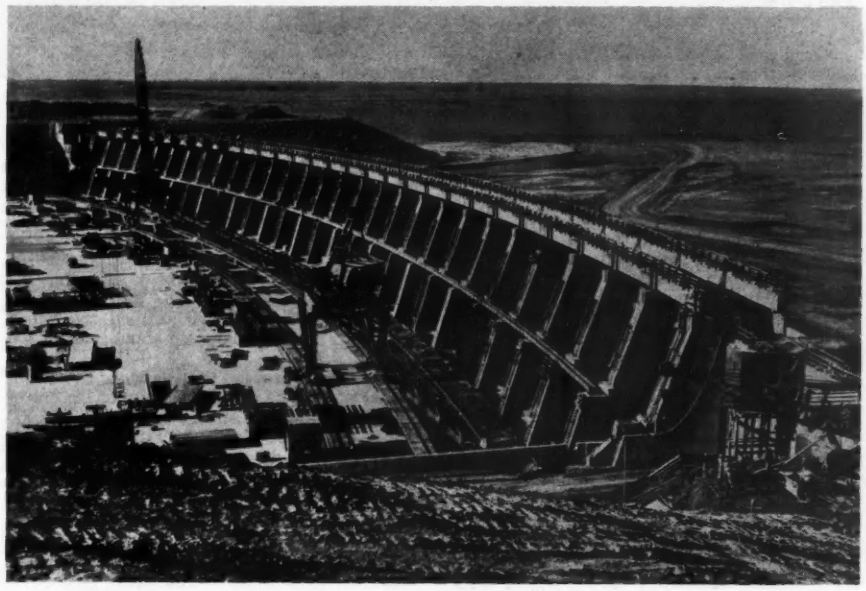


Fig. 2—Spillway section of Garrison dam of the U.S. Army Corps of Engineers on the Missouri River

Folsom Dam

All three 54MW Francis turbo-generators at the Folsom dam power station went into operation during the past year, and the dam structure on the American River near Sacramento, California, has also now been completed. While this structure is of considerable importance from the point of view of local flood control, irrigation and power generation, it is of even greater interest to American civil engineers as the first major case of co-operation between the U.S. Army Corps of Engineers and the U.S. Bureau of Reclamation. In this particular case the dam has been constructed by the former and the power station by the latter body. The Folsom dam has created a reservoir with a gross capacity of, 1,000,000 acre-feet. Of this, about 88,000 acre-feet is utilised to maintain a minimum power pool while the remaining 912,000 acre-feet is operated in the joint interest of flood control, municipal and industrial water supply, irrigation, power and incidental recreation use. The maximum flood control reservation, which varies seasonally with the flood hazard, is 400,000 acre-feet. The Folsom power turbines have a gross head ranging from 196ft to 336ft and an installed

Fig. 3—Aerial view of Fort Randall dam of the U.S. Army Corps of Engineers on the Missouri River

capacity of 162MW. The concrete river section of the dam, which is illustrated in Fig. 1, is founded on fresh granite rock. The earth wing dams and eight of the saddle dikes are, in general, founded on decomposed granitic soils, their cut-off trenches being taken down through surface soils of relatively light density to weathered but firm granite.

The maximum height of the concrete river section of the dam, from foundation to roadway, is 340ft, and the combined length of the concrete overflow and non-overflow sections is 1400ft. All sections of the dam were designed as vertical gravity sections, 1ft wide, under various assumptions as to pool and tailwater elevations, uplift and earthquake loading. Each of the eight Tainter gates on the spillway crest is operated by its own motor-driven hoist. The five-bay river spillway section has four 5ft by 9ft sluice outlets in each of two tiers. Each sluice is controlled by two 5ft by 9ft hydraulically operated slide gates in tandem, one acting as the service gate and the other as an emergency gate. An 8ft by 15ft fixed-wheel face gate is also provided to give access to the sluices for maintenance. An operating bridge and roadway are provided over the spillway section, and rails extend across the concrete dam for a gantry crane to operate the face gate and the penstock emergency gates.

On the axis of the dam the low-water width of the river is limited to about 250ft. Hydrologic and hydraulic studies by the Corps of Engineers indicated that, to protect the dam from overtopping under an extreme, but theoretically possible, combination of events, the spillway should have eight Tainter gates, 42ft wide by 50ft and 54ft in height. In the narrow river channel only five 50ft high gates could be economically provided with a conventional hydraulic jump stilling basin. The other three gates, 54ft in height, are situated on the left abutment immediately adjacent to the main spillway section. These three gates have no provisions for dissipation of energy, but do incorporate a "flip bucket" near the toe of the dam, so that, if and when they go into operation, the impact of the spilling water will not endanger the safety of the dam. Operation of these gates would be a rare event in any case, as even without considering the reduction of a peak storage or surcharge, the five main gates alone can pass an uncontrolled peak inflow of about 300,000 cusecs, which theoretically may be expected about once in 500 years.

The stilling basin has been designed to prevent objectionable surges in the vicinity of the power plant for flood control releases up to 115,000 cusecs, and to contain the hydraulic jump for all spillway flows up to 300,000 cusecs. Three 15ft 6in diameter steel-lined penstocks, which are controlled by fixed-wheel emergency gates, pass through the right abutment non-overflow section to serve the power plant. The concrete river section is enveloped on both ends by large earth wings having a maximum height of 145ft, a combined length of 9000ft, and a combined volume of about 7,800,000 cubic yards. Both wing dams incorporate an impervious core with a pervious shell. The cut-off trench backfill and the impervious zone consist of compacted decomposed granite, while the pervious shells consist of natural river gravels, dredge tailings and surplus rock from excavation. Riprap protection, from rock obtained from excavation, is provided on the water face of the wing dams. Their crest width is 30ft and their downstream and upstream slopes are 1 in 1 and 1 in 2¼ respectively. The sections were designed by the circular arc method of analysis with earthquake loading considered.

Garrison Dam

Much progress was made last year in the construction by the U.S. Army Corps of Engineers of the Garrison dam and reservoir on the Missouri River in North Dakota, which is to serve for flood control, power generation, irrigation, navigation and stream sanitation. At maximum normal operating level the Garrison reservoir will have a total capacity of 23,000,000 acre-feet, covering a length of 217 miles, a maximum width of 14 miles and an area of 390,000 acres. It is believed that this will make it the largest man-made lake in the world. The dam is a rolled earth-fill structure, which will be 12,000ft long at the crest, with a maximum height of 210ft and a maximum base width of 2600ft. The crest width will be 60ft and the side slopes will range from 1 in 8 and 1 in 10 in the lower portion of the embankment to 1 in 2½ in the top portions. The ultimate total volume of the embankment will be 70,000,000 cubic yards, and nearly all the fill materials are to be obtained from the excavations for the spillway and the outlet works channels. The embankment foundation consists of alluvial sand, extending as deep as 110ft on the east side of the river, and outwash clays with sand and gravel lenses on the west side. Underlying these materials and extending up to or near the surface on both sides of the river is the bedrock formation, which is highly consolidated and consists largely of clayey materials.

A system of outlet works has been provided in the west abutment of the dam for diversion of the river during the closure stage of dam construction and for the permanent control of water. The outlet works consist of eight tunnels through the dam, an intake structure with control gates at their upstream ends, and a stilling basin and power plant at their downstream ends, with excavated channels leading to the river, both upstream and downstream. The eight tunnels are nearly parallel in alignment, are each about 1200ft long, are all circular in cross section and have reinforced concrete linings. Five of the tunnels, each having a 29ft inside diameter, will serve as conduits for 24ft diameter steel penstocks leading to the turbines. The three most westerly tunnels will serve for reservoir regulation, discharging into a concrete stilling basin; two of these tunnels have an inside diameter of 22ft and the third tunnel one of 26ft. Each of the three regulating tunnels is served by a single sector gate, 24ft 6in high by 18ft wide. Each of the five power tunnels is served by two vertical lift "caterpillar" gates, each 26ft high by 12ft wide, with a dividing pier between them. The concrete stilling basin is of the design conventionally employed for dissipating the energy of water flowing freely at high velocities from the end of a conduit. It is divided into three units to allow for operation of the three regulating tunnels individually or in any combination. Under maximum head and maximum flow conditions the height of the hydraulic jump in the stilling basin will be about 30ft. The overall dimensions of the structure as required to develop and contain the hydraulic jump for all three tunnels are as follows: length 470ft, maximum height of walls above floor of stilling basin 71ft, and width of basin 260ft.

The power station at the dam ultimately will consist of five 80MW turbo-generator units, three of which will be installed within the initial scheme of construction and the other two at a later date. Due to the length of the penstocks, two steel surge tanks, 65ft diameter by 135ft high, are being provided on each penstock at a point a short distance upstream from the power station. Provision is being made for complete enclosure of the surge tanks and the penstocks

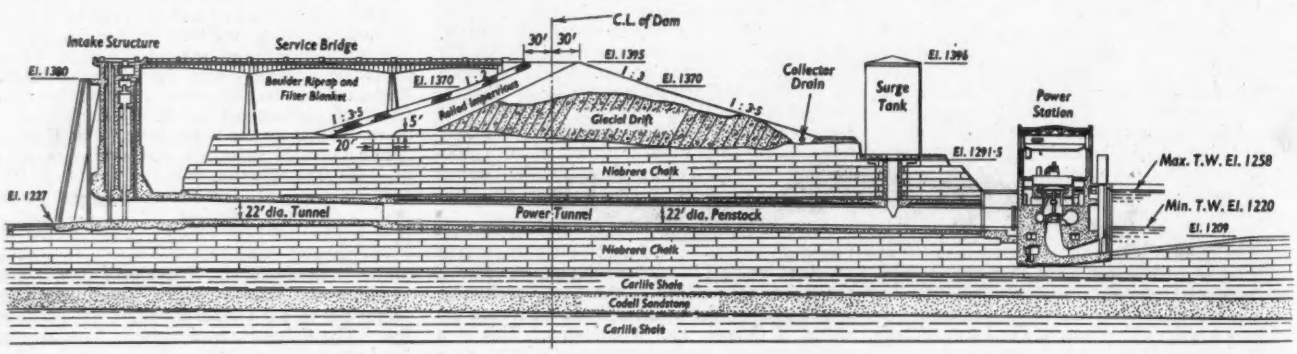


Fig. 4—Sectional arrangement of Fort Randall dam on the Missouri River

to obtain protection against excessive ice formation. The turbines are vertical shaft Francis units, having runner diameters of 210½in, rated at 88,000 h.p. at or near maximum efficiency at a 150ft head. The first one of these unit went into operation last summer and it is expected that the ultimate installation of five units will have a dependable capacity of 297·5MW, and an average annual gross energy output of 1,712,000,000kWh.

The spillway, which is shown in Fig. 2, is situated high in the east abutment of the dam, and was completed in August, 1955. Its design capacity is 827,000 cusecs at a reservoir level 16ft below the crest of the dam, and it is of concrete construction, with gate control at an ogee weir at the upstream end, where there are twenty-eight sector gates, each 40ft long by 29ft high, individually operated by electric hoists mounted on the piers.

Fort Randall Dam

The construction of Fort Randall dam, another major structure within the Missouri River Basin, was essentially completed by the U.S. Army Corps of Engineers during 1955, and seven of its eight 40MW turbo-generators are now in operation. The structure, which is shown in Fig. 3, provides an important storage reservoir within the Pick-Sloan comprehensive plan for the conservation and utilisation of water resources of the Missouri River Basin. It is situated on the Missouri River in south-eastern South Dakota and, together with the other large Missouri River dams situated upstream, it will control the run-off of an area of 263,480 square miles. The reservoir will have a capacity at maximum operating pool of approximately 6,300,000 acre-feet. At minimum flood control pool the reservoir will have an area of 81,700 acres and will extend upstream approximately 140 miles.

Practically all the materials used in constructing the dam embankment were excavated from the outlet works and spillway sites. About 26,000,000 cubic yards of glacial drift overburden materials and about 19,000,000 cubic yards of chalk and shale bedrock were excavated from these sources and placed in the embankment. The central part of the dam is a rolled fill of glacial overburden materials, and the more pervious overburden was placed in the downstream third of this zone. An impervious blanket was provided to lengthen the seepage path under the dam. It extends 1500ft upstream from the toe of the rolled embankment and varies in thickness from 10ft at the upstream end to 20ft where it joins the rolled embankment section. This blanket is composed of glacial overburden material placed in 12in lifts. Compaction was obtained by not less than three passes of the spreading equipment. The embankment section is founded on top of the chalk formation and is composed of part natural glacial drift left in place and part rolled glacial materials. A layer of select impervious fill was placed on the upstream slope, varying in thickness from about 15ft near the crest to 20ft near the base. The layer was keyed into the top of the bedrock surface by a trench 20ft wide and 5ft deep. Boulders stockpiled from glacial overburden excavation were used as riprap on the upstream slope of this section, with a filter of spalls and sand-gravel as backing. A pervious toe drain and collector pipe was placed at the toe of the embankment over the tunnels.

The outlet works were used first for the diversion of the river and then for releasing water from the reservoir for the generation of power or the regulation of river flow. The outlet works consist of an approach channel, an intake structure and twelve tunnels, eight of which conduct water to the turbines and four of which provide an outlet discharge capacity of approximately 107,000 cusecs with the pool at the spillway crest. A combined tailrace and discharge channel leads the flow back to the river channel. Of the twelve tunnels, three have a finished diameter of 22ft. The other nine have a finished diameter of 22ft for 215ft upstream and of 28ft in the remaining 655ft downstream.

As shown in Fig. 4, the intake structure consists of twelve reinforced concrete towers connected monolithically into pairs and bridged together at the top to form a continuous deck. Each tower is 180ft high, 46ft wide, and varies in depth in the direction of flow from 110ft at the base to 50ft at the top. The total length of the top or gantry deck is 827ft. Each of the twelve towers contains two 11ft by 23ft water passages, each provided with service gate slots, emergency gate slots, bulkhead slots and a removable trashrack. Each service gate has an individually operated hoist situated below the gantry deck. The four emergency gates, which are identical and interchangeable with the service gates, permit emergency closure of two tunnels simultaneously. A spare hoist for operating the emergency gates is stored in a space between towers. When needed, the hoist may be lifted and set in place on the gantry deck by means of the 125-ton electric travelling gantry crane. A 15-ton auxiliary hoist with an overhanging trolley travel projecting upstream from the gantry crane is used to handle the bulkheads and trashracks. The mechanical and electrical equipment for the operation of gates and for the maintenance and repair of gates is enclosed within the towers.

Twelve tunnels in the left abutment serve to pass water through the dam. The abutment at the tunnel site is composed of a 145ft thick layer of Niobrara chalk overlain by glacial overburden. Free-standing steel penstocks, 22ft in diameter, have been installed in the tunnels with a finished concrete diameter of 28ft.

The power station will ultimately comprise eight main generating units with Francis turbines rated at 57,500 h.p. each under 112ft of head, with a speed of 85·7 r.p.m. The generators will deliver 42,105kVA at 95 per cent power factor and 13·8kV. Four of the generating units have been equipped with high-speed governors, and their penstocks are provided with surge tanks. The other four units are intended to operate on "blocked load" and are equipped with slow-speed governors. To avoid the fabrication of extra thick shell plates and to distribute the foundation loading over the tunnels, eight surge tanks were constructed, operating in pairs on each of the four regulating units. The surge tanks are of the restricted-orifice type, 59ft in diameter and 100ft high.

The spillway, which is shown under construction in Fig 5, is situated in the left abutment of the dam landward from the outlet works. Its construction was divided into two stages. Stage 1 included construction of the approach channel walls and slabs, the gate structures, including the weir, piers, pier extensions, pier extension slabs, spillway bridge and Tainter gates, abutment structures and downstream abutment walls. Stage 2 included the chute and the stilling basin downstream from Stage 1. The mass concrete overflow weir extends in a straight line between abutments and is divided into twenty-one bays 40ft long by twenty 8ft piers extending over a total length of 840ft. The upstream face of the weir is vertical, and the top and downstream face is in the form of an ogee curve with a crest elevation of 1346ft, or 21ft above the approach channel floor. To control the discharge over the weir there are twenty-one 40ft by 29ft Tainter gates individually operated by electrically driven hoists placed near the top of the piers and abutments beneath the spillway bridge. The bridge is a deck structure seated on the piers and abutments to accommodate the highway across the top of the dam. Each pier contains access shafts and ladders leading from the hoist level to a trunnion access level. Each pier is extended downstream from the weir for a distance of 30ft to serve as a training wall.

The spillway chute is 1000ft wide with a 4 per cent slope for a distance of 1020ft and a 20 per cent slope for a distance of 400ft to the floor of the stilling basin. The stilling basin is 200ft long.

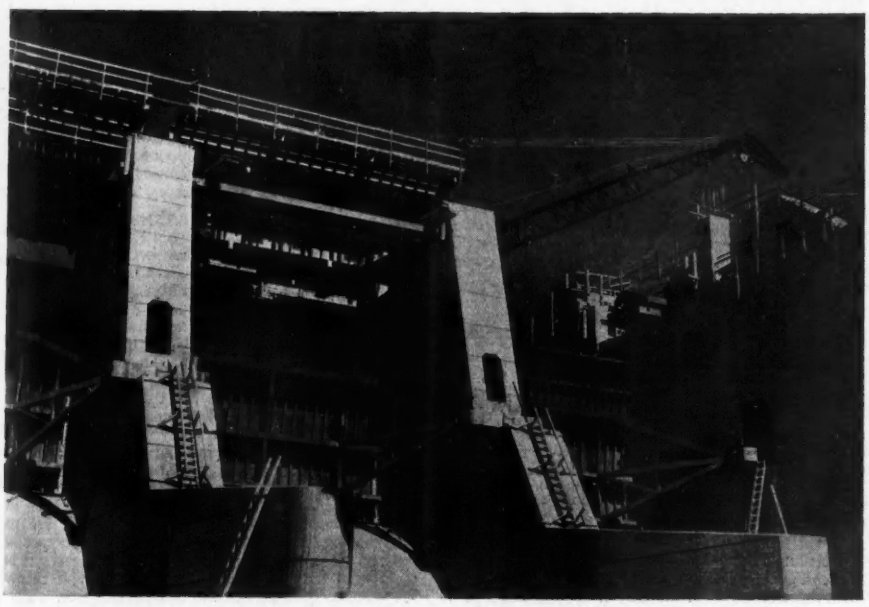


Fig. 5—Part of Fort Randall dam spillway structure with 40ft by 29ft Tainter gates

Storm Surge Investigation

A THREE-YEAR investigation to test the theory that several hours' warning of storm surges can be given, is to be carried out at Columbia University, with an Engineering Foundation grant.

It is believed that when a line squall with its accompaning area of high pressure travels over water at a velocity equal to the normal velocity of a wave of water of the particular existing depth, a resonant effect is produced which can augment the normal wave. Fortunately the critical combination of atmospheric disturbance and natural wave period rarely occurs, but the Lake Michigan surge of 1954 appears to have been one of these rare instances.

Since only for equal velocities can a large wave be generated, the investigation will have to show that appropriate velocities existed at the time of the surge. Trial forecasts of lake surges will be made based on studies from U.S. Weather Bureau records of past storms and surges. Continuous monitoring of the kind of atmospheric disturbances thought responsible for the Lake Michigan class of surge will be undertaken with a new instrument sensitive enough to record disturbances that might generate small surges. The instrument—made especially for the project and called the Wallace microbarograph—is being installed at a lake station. A water level recorder will also be installed at a lake station and operated by the U.S. Lake Survey. The investigations will be extended to the coastal oceanic type of flood, with the Atlantic flood of November, 1953, the special case study.

Personal and Business

Appointments

MR. E. S. PEARSON has been appointed deputy chairman of Clarkson (Engineers), Ltd., Nuneaton.

MR. R. H. STUBINGTON has been appointed a director of Merryweather and Sons, Ltd., Greenwich, S.E.10.

RUSTON-BUCYRUS, Ltd., Lincoln, states that its secretary and chief accountant, Mr. F. T. Hartland, has been appointed a director.

MR. G. J. WILLMOTT has been appointed a director of the Gear Grinding Company, Ltd., Cranmore Boulevard, Shirley, Birmingham.

MR. R. S. SEARLE has been appointed assistant managing director of Parsons Chain Company, Ltd., and its subsidiary, British Wire Products.

MR. A. R. M. GEDDES, a director of Dunlop Rubber Company, Ltd., has been elected chairman of the council of the International Road Federation.

B.I.P. ENGINEERING, Ltd., Streetly, Staffs, states that Mr. F. E. Mills, sales director and general manager, has been appointed managing director.

MR. G. ORMISTON has been appointed engineering adviser, and Mr. R. R. Strachan, superintendent engineer, of the New Zealand Shipping Company, Ltd.

MR. T. G. QUINNEY has relinquished his seat on the board of Drummond-Asquith (Sales), Ltd., to become managing director of A.M.T. (Birmingham), Ltd., Birmingham.

MR. GEOFFREY W. G. TEW, A.M.I.Mech.E., has been appointed works manager at the Wolverton carriage and wagon works, British Railways (London Midland Region).

INGERSOLL-RAND COMPANY, Ltd., 165, Queen Victoria Street, London, E.C.4, states that Mr. L. R. Hewitt, general sales manager, has been appointed a director.

MR. P. NELSON GRACIE has been appointed senior liaison officer of Folland Aircraft, Ltd., Hamble, Southampton, in succession to Group Captain S. O. Tudor, who has resigned.

MR. W. R. JONES, managing director of George Clark and North Eastern Marine (Sunderland), Ltd., has been appointed a director of the parent company, Richardsons, Westgarth and Co., Ltd.

SIR IVOR COX has been appointed deputy chairman of A.E.I. Overseas, Ltd. He has been succeeded as group managing director of Associated Electrical Industries, Ltd., by Mr. F. J. E. Tearle.

SAMUEL FOX AND CO., Ltd., Sheffield, states that Mr. A. C. Brierley has been appointed to succeed Mr. J. H. Goodlad as light steel sales manager. Mr. C. M. Slocombe has been appointed a director of the company.

CANTIE SWITCHES, Ltd., announces the appointment of Mr. F. Nye as London and home counties manager. He succeeds Mr. R. W. Hayward, who has left the firm in order to practice as an engineering consultant.

MR. W. CLIFFORD LONG, MR. FREDERICK BROWN and MR. THOMAS M. ELLIOT have been appointed to the board of Arthur Lee and Sons, Ltd., Sheffield. They have also been appointed directors of Arthur Lee and Sons (Hot Rolling Mills), Ltd., and Arthur Lee and Sons (Cold Strip), Ltd.

DORMAN, LONG AND CO., Ltd., states that Mr. S. Barlow has been appointed general manager of Dorman Long (Bridge and Engineering), Ltd. He was formerly manager of the bridge and constructional works. Mr. E. Ibbotson has been appointed manager of the company's Britannia constructional works.

THE GENERAL ELECTRIC COMPANY, Ltd., Magnet House, Kingsway, London, W.C.2, states that Mr. D. A. Strachan has been appointed to the head office to take charge of flameproof and mining equipment sales. Mr. S. C. Wells has been appointed to take responsibility for oil industry equipment sales.

WICKMAN, Ltd., Coventry, states that Mr. G. R. Marsh has retired from the office of managing director. He will continue to serve on the board. Mr. E. A. Hyde has been appointed managing director and Mr. W. V. Hodgson, deputy managing director. Mr. C. F. Watts has been appointed financial controller, and Mr. H. B. Morris, secretary of the company.

THE MOND NICKEL COMPANY, Ltd., states that Mr. F. B. Howard-White has been appointed to the delegate board. Since May of last year he has been a director of Henry Wiggin and Co., Ltd. The Mond Nickel Company, Ltd., has also announced the appointment of Mr. E. R. Perry as a development officer in the platinum metals division of the development and research department at Acton.

MR. WILFRED D. C. HUSKISSON has accepted an appointment from the United Nations Technical Assistance Administration as an expert on plastics to the Government of India. This appointment, which is for eighteen months, has been made at the request of the Indian Government and is part of the programme of the United Nations and its specialised agencies to assist less-developed countries in solving industrial problems.

Business Announcements

THE GYPSUM BUILDING PRODUCTS ASSOCIATION states that its address is now G.P.O. Box No. 321, London, W.1.

ACROW (ENGINEERS), Ltd., 7, South Wharf, London, W.2, has purchased land at Orangeville, Ontario, for the construction of a factory.

HEAD WRIGHTSON PROCESSES, Ltd., Teesdale House, 24–26, Baltic Street, London, E.C.1, states that its telephone number has been changed to Clerkenwell 1299.

THE ASTON CHAIN AND HOOK COMPANY, Ltd., Erdington, Birmingham, has opened a London office at 49, Conduit Street, W.1. Mr. John H. Randall is the manager.

G. MAUNSELL AND PARTNERS state that their consulting engineering practice is now carried on from 7, Cleveland Row, Westminster, London, S.W.1 (telephone, Trafalgar 1788).

THE HAMPTON LAUNCH WORKS, Ltd., Platt's Eyot, Hampton-on-Thames, Middlesex, states that its name is to be changed on February 1st to Thornycroft (Hampton) Boatyard, Ltd.

FIELDEN ELECTRONICS, Ltd., Wythenshawe, Manchester, has opened a Midlands office at 18, Wolverhampton Street, Dudley. Mr. F. Bernard Price is the engineer in charge of the office.

LEYLAND MOTORS, Ltd., has signed an agreement with Van Doorne's Automabielfabrick N.V., Eindhoven, Holland, permitting the latter company to manufacture Leyland and Albion diesel engines.

THE TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY, Ltd., and its associate company, Submarine Cables, Ltd., have moved their head offices to Mercury House, Theobald's Road, London, W.C.1 (telephone, Holborn 8711).

BAKELITE, Ltd., which acquired Warerite, Ltd., in 1939, states that it now produces and sells all the "Warerite" materials. Inquiries for these materials should therefore be sent to Bakelite, Ltd., 12-18, Grosvenor Gardens, London, S.W.1.

NORTHERN ALUMINIUM COMPANY, Ltd., has opened a new sales office at 16, Cumberland Place, Southampton (telephone, Southampton 25425). Another sales office is to be opened on January 16th at 57, Bute Street, Luton, Beds (telephone, Luton 7364). The company's Manchester area sales office has been moved to 23, Princess Street, Manchester, 2 (telephone, Central 9335).

Contracts

RANSOMES AND RAPIER, Ltd., Ipswich, has received another order for a "W1400 Walking Dragline" from Stewarts and Lloyds, Ltd. The "Rapier W1400," which weighs 1650 tons, carries a 20 cubic yards dragline bucket on a 282ft long boom, is powered by two 1500 h.p. motor generator sets running on 6000V supply.

BRITISH INSULATED CALLENDER'S CABLES, Ltd., has received from The Sudan Light and Power Company, Ltd., an order for approximately 7 miles of 33kV aluminium-sheathed impregnated pressure cable for the new transmission line from Burri power station, Khartoum, to Omdurman. It is anticipated that the installation work will begin in the spring or early summer. The route will include a crossing of the White Nile.

Miscellanea

MUSEUM ADVISER FOR CEYLON.—The Science Museum has announced that Mr. W. T. O'Dea, Keeper of the Department of Aeronautics and Sailing Ships, has been released for three months to undertake an exploratory mission for Unesco as technical assistance expert in Ceylon under the Colombo plan. He will advise the Government of Ceylon on the establishment of a science museum at Colombo and will call at New Delhi on his return journey to discuss with representatives of the Government of India their proposals for science museums in four widely separated localities.

INSTITUTION OF MINING ENGINEERS.—The Institution of Mining Engineers has announced the election of Dr. William Reid as president for 1956-57. He will deliver his presidential address, entitled "The Changing Techniques and Management of the Coal Industry," at the annual general meeting, which is to be held on Thursday, January 26th at 11.45 a.m. at the Institution of Naval Architects, 10, Upper Belgrave Street, London, S.W.1. Prior to the meeting, at 11 a.m., the war memorial at the Institution's headquarters at 3, Grosvenor Crescent, S.W.1, will be unveiled by the retiring president, Major Noel E. Webster.

GAS TURBINE TECHNOLOGY.—A series of ten lectures for mechanical engineers of graduate standard, at the Northampton Polytechnic, St. John Street, London, E.C.1, on "An Introduction to Gas Turbine Technology," will be given by Mr. R. C. Orford, patent manager of Power Jets (Research and Development), Ltd. The course will include the early history of the internal combustion turbine and deal with its application to aircraft and a range of industrial processes. The lectures will be given on Tuesday evenings, commencing January 17, 1956. Application for enrolment should be made to the Northampton Polytechnic.

TOOLHOLDERS.—We are informed by Denford Small Tools (Brighouse), Ltd., Birds Royd, Brighouse, Yorks, that this firm is now manufacturing a new range of American type toolholders. These holders are made of case-hardened nickel-chrome steel and cadmium-plated. The straight, right and left-hand turning toolholders are made in six sizes for cutters from $\frac{3}{16}$in to $\frac{1}{2}$in in increments of $\frac{1}{16}$in. An external thread cutting tool has a cam form cutter, which can be adjusted to suit centre height, and the cutters are available for different thread forms. Three sizes of parting-off and side-toolholders, a knurling toolholder, and a double-ended boring bar holder are also available in the new ranges made by the firm.

GERMANIUM RECTIFIER TRAIN.—The British Transport Commission states that successful trials have been carried out recently on the Lancaster-Morecambe-Heysham line (London Midland Region) with an electric train equipped with a B.T.H. germanium rectifier. The rectifier is air-cooled and is of 750kW capacity, arranged for full-wave rectification. It is intended to continue with electric traction on the Lancaster-Morecambe-Heysham line, but the electric service has been temporarily suspended in order to modernise the overhead wire system, most of which has been in use for nearly fifty years. As soon as this renovation has been completed, electric working will be resumed and the germanium rectifier train will enter passenger service.

CAST IRON RESEARCH.—The thirty-fourth annual report of the British Cast Iron Research Association, which was published recently, surveys the work accomplished in the year 1954-55. The report says that there is need for a measure of expansion for the Association's general research and development activities. It is therefore intended to provide a new research block to house the whole of the experimental research work. The total cost of the building and equipment is put at £50,000. Dealing with research programmes, the report says that it is highly desirable that the Association should explore the technical possibilities of reducing the phosphorus content of native pig irons without loss of carbon, such as takes place in the basic Bessemer process. In order to prepare a suitable programme, a "phosphorus panel," under the chairmanship of Mr. E. Morgan, has been established by the Association's research board.

DRILLING CAST IRON.—An article in the December issue of the *PERA Bulletin* draws attention to a report on drilling cast iron which has been issued by the Association. The article deals with the effect of point shape when drilling cast iron and states that in a series of closely controlled drill life tests point angles varying between 120 deg. and 60 deg. were used. It was found that drill life increased rapidly as the point angle was reduced. The total number of holes drilled (without a regrind) using four drills with a 60 deg. point angle was over 2500, while the total number of holes drilled using four drills with a point angle of 120 deg. was only twenty-two. Thus, a drill with a 60 deg. point had an average life of 650 holes, and one with a 120 deg. point had an average life of only five or six holes between regrinds. It is pointed out that these extreme differences in drill life could in some measure have been due to high cutting speeds which were used and the special test rig. But even allowing for these influences it is considered that the reduction of point angle below the values commonly used in drilling cast iron would clearly have a marked effect on the performance of drills under normal workshop conditions.

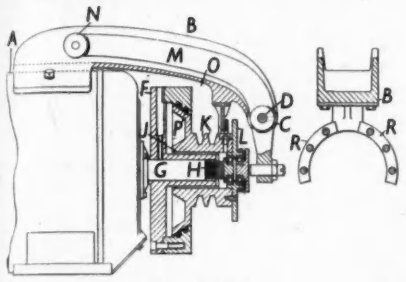
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgement is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgement, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. each.

ELECTRICAL ENGINEERING

738,734. March 30, 1951.—CLUTCH AND BRAKE PULLEY DRIVING MECHANISM FOR ELECTRIC MOTORS, The Marine Engineering Company (Stockport), Ltd., 14, Bulkeley Street, Edgeley Stockport. (*Inventors: Frederick Smith and Benjamin Gordon Mann.*)

The invention relates to an improved clutch and brake mechanism for electric motors, for industrial machines such as laundry machines, looms and sewing machines. As shown in the drawing, a bracket *B* overhanging the end of the motor is attached to the motor casing *A* by bolts. It is of channel section, the base of this section being discontinued a short distance from the end where the sides of the channel are formed as bosses *C* for a bearing pin *D*, secured

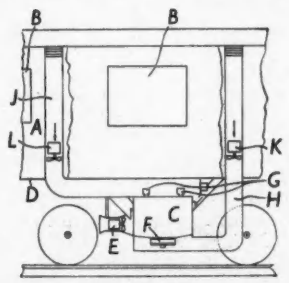


No. 738,734

by set screws. On its underside the base of the bracket is formed with a facing which is rebated to take a "C"-shaped brake bracket. A flywheel *F* is secured to the motor shaft *G* by set screws, and it has a long hub recessed to form a housing for the spring *H*. The face of the pulley is recessed to take the thrust plate housing. Journalled by a bush *J* is a twin grooved belt pulley *K*. Attached to the outer end of the plate brake is the thrust plate *L* and a double row of ball thrust races with a dust cover. In the channel is a cranked clutch and brake actuating lever *M* pivoted on the bearing pin *D* and at its end is a thrust pin engaging the centre of the thrust plate *L*. At the top end of the lever *M* are bosses *N* for attachment to linkage such as a treadle or solenoid. The cone clutch consists of a female element *O* with friction rings, and a male cone *P* cast on to the end of the pulley. The brake lining *R* is stationary and is secured to the bracket. In use, the spring *H* holds the male cone *P* normally in engagement with the two friction rings on the female member *O*. Actuation of the lever *M* serves to disengage the clutch and engage the brake ring *L* with the brake lining *R*. Another example of construction with a flat disc clutch is also shown in the specification. —*October* 19, 1955.

740,895. July 16, 1952.—ELECTRIC CONVERTER ARRANGEMENTS, The General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2, and William George Thompson, of The General Electric Company, Ltd., Engineering Works, Witton, Birmingham.

The invention relates to electric converter arrangements, particularly for use in electric traction schemes in which at least one d.c. traction motor on a motor coach is supplied from an a.c. line by way of metal-clad vapour electric arc rectifying means also mounted on the motor coach. Referring to the drawing, the coach *A* with windows *B* has a pumpless steel-clad



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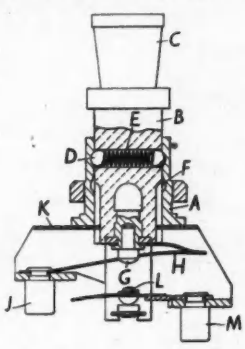
mercury arc rectifier *C* mounted beneath the floor *D* of the coach. This rectifier *C* supplies one or more d.c. traction motors. To cool the rectifier the main tank is associated with one electrically-driven fan *E* which draws air from beneath coach floor level whilst air for cooling the cathode seal *F* of the rectifier and for cooling the anode seals *G* of the rectifier, is drawn from a level well above the floor *D*. For this purpose a duct *H* leads from roof level to the cathode seal *F*, whilst a similar duct *J* is provided for the anode seals *G*, an electrically-driven fan *K* or *L* being provided on each duct. Suitable venting arrangements are provided for the air after it leaves the cathode and anode seals.—*November* 23, 1955.

739,071. September 17, 1952.—THERMALLY-RESPONSIVE ELECTRIC SWITCHES, C.A.V., Ltd., Warple Way, Acton, London, W.3. (*Inventor: Albert Victor Waters.*)

The invention provides a simple electric pull-push switch adapted to serve also as an automatic thermally-operable circuit-breaker in the event of an overload. Referring to the drawing, a hollow body part *A* having a cylindrical bore, has a plunger *B* which at its outer end is provided with or is shaped to serve as a finger piece *C*. The "on" and "off" positions of the plunger are determined by a ball catch or catches *D* loaded by a spring *E* to engage recesses *F* in the bore of the body. At the inner end of the plunger is secured a contact piece *G*,



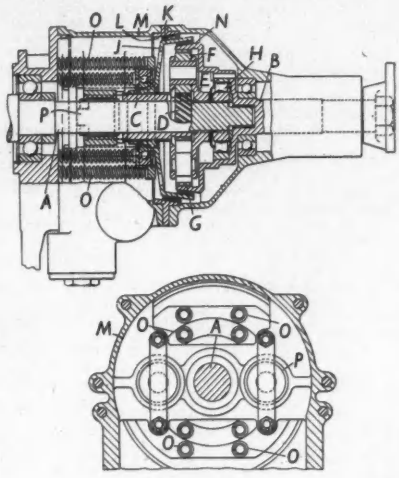
No. 739,071

and this is connected by a flexible metal strip *H* to a circuit terminal *J* carried by a part *K* which is secured to one end of the body *A*. The complementary contact piece *L* is formed on or secured to a flexible and elastic bi-metal component which requires to be reset after thermal deformation, this component being secured to another circuit terminal *M* on the part *K* of the switch. To close the switch, the contact pieces are brought together by inward movement of the plunger. So long as the current then flowing through the switch is within a predetermined amount, the contact pieces remain in mutual contact, and to open the switch the plunger is retracted. But in the event of an overload, the bi-metal component is thermally deformed and separation of the contact pieces is thereby effected automatically. Restoration of the component to its normal condition after cooling is effected by retraction of the plunger.—*October* 26, 1955.

POWER TRANSMISSION

739,126. September 8, 1953.—EPICYCLIC POWER TRANSMISSION MECHANISMS, AUTO TRANSMISSIONS Ltd., Upper York Street, Coventry. (*Inventor: Sydney Henry Ashby.*)

The invention relates to two-speed epicyclic power transmission mechanisms for use more particularly on road vehicles, and of the type such as is described in Specification No. 456,007. The object of the invention is to enable the frictional grip of the clutch member on the part with which it is engaged to be automatically supplemented by an action derived from the sun pinion. As shown in the drawings a two-speed over-drive mechanism for use on a road vehicle has the power input shaft *A* and the power output shaft *B* mounted coaxially. On the input shaft is a sleeve *C* on which is a sun pinion *D*. The carrier *E* for the planet pinion or pinions *F* is secured to the input shaft, and an internally toothed annulus *G* is secured to the output shaft. A unidirectional clutch *H* is set between the annulus and either the input shaft or the planet pinion carrier. According to the invention all the toothed gear elements employed are of the helically toothed type, and the sleeve *C* also has axial freedom of movement on the shaft *A*. To the sleeve is secured a friction clutch member *J* which has an overhanging circumferential flange *K* of truncated conical form, the outer surface of the flange co-operating with a complementary surface *L* on the housing *M* for holding the sun pinion stationary, and the inner surface co-operating with a complementary surface *N* on the annulus for interlocking the input and output shafts. Actuation of the movable clutch member *J* is effected in one direction by springs *O*, and in the opposite direction by the plungers *P* of hydraulic or other mechanism. The arrangement is such that when the movable clutch member *J* is engaged with the housing and the vehicle is being driven in the forward direction, the interaction of the sun and planet pinions exerts an



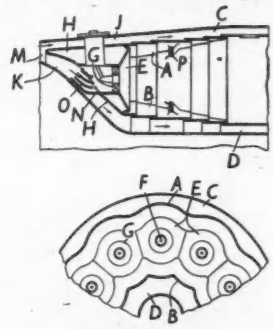
No. 739,126

axial thrust on the member in the direction for increasing its grip on the housing. A like effect is obtained when the member is engaged with the annulus and the vehicle is driven in reverse, or during descent of a hill in the forward direction under the impetus of the vehicle. In either case the grip increases with increase of torque.—*October* 26, 1955.

GAS TURBINES

739,093. March 5, 1953.—COMBUSTION CHAMBERS FOR GAS TURBINES, Joseph Lucas (Industries), Ltd., Great King Street, Birmingham, 19. (*Inventors: John Stanley Clarke, Squire Ronald Jackson and Geoffrey John Hudson.*)

The invention relates to an annular combustion chamber for a jet propulsion engine, gas turbine, or other prime mover having an air jacket around both its inner and outer walls. The object of the invention



No. 739,093

is to provide an improved construction whereby air supplied by a blower can be conveyed to the entrance end of the combustion chamber in a more satisfactory manner than heretofore. Referring to the drawing, the annular combustion chamber of sheet metal has for its outer and inner cylindrical walls *A* and *B* overlapping sections of corrugated form. The combustion chamber is surrounded by outer and inner air jackets *C* and *D*. The entrance end of the combustion chamber is wholly or partially closed by an annular end wall *E* on which are mounted the liquid fuel nozzles *F*. Around each nozzle is an air orifice *G* containing air swirling vanes. As shown, the end wall is constructed from a series of segments each shaped to form a conical cavity around each nozzle. At the end of the combustion chamber is formed or secured a hollow annular nose piece *H*, which, together with the surrounding extensions of the outer and inner walls of the air jackets, forms a pair of passages *J* and *K* respectively leading from annular entrance *M* to the outer and inner air jackets, the outer one of these passages being preferably situated in line with the outer air jacket. In one of the walls of the nose piece are equi-spaced gaps situated in line with the air orifices *G* and in each gap is inserted a tubular scoop *N*. Each scoop at its entrance end projects into the air passage *K* leading to the inner air jacket, and the other end is connected to the corresponding air orifice *G* in the end wall of the combustion chamber. Preferably in each of the scoops there is a number of guide vanes *O*. Alternatively, the scoops may be arranged to gather air from the passage leading to the outer air jacket. Additional air can be supplied through the short ducts *P*—*October* 26, 1955.

Calendars and Diaries

We acknowledge receipt of calendars and/or diaries for 1956 from the undermentioned firms :—

Office of the High Commissioner for the Union of South Africa, South Africa House, Trafalgar Square, London, W.C.2.

J. E. Raistrick, Ltd., Reliance Works, Poyle Trading Estate, Poyle Road, Colnbrook, Slough, Bucks.

Wild-Barfield Electric Furnaces, Ltd., Otterspool Way, Watford By-Pass, Watford, Herts.

Colton Electrical Equipment Company, Ltd., Moor Lane, Cranham, Upminster, Essex.

North British Locomotive Company, Ltd., 82, Victoria Street, London, S.W.1.

The Northern Manufacturing Company, Ltd., Albion Works, Gainsborough.

The David Brown Corporation (Sales), Ltd., 96/97, Piccadilly, London, W.1.

F. J. Edwards, Ltd., Edwards House, 359–361, Euston Road, London, N.W.1.

Fischer Bearings Company, Ltd., Upper Villiers Street, Wolverhampton.

Ben Thornton and Partners, Ltd., 39, Victoria Street, Westminster, S.W.1.

Nettle Accessories, Ltd., Harper Road, Wythenshawe, Manchester.

Davidson and Co., Ltd., Sirocco Engineering Works, Belfast, N. Ireland.

Aktieselskabet Metallic, 12, Ellekaer, Herlev-Copenhagen, Denmark.

Joshua Bigwood and Son, Ltd., Wednesfield Road, Wolverhampton.

C. A. Parsons and Co., Ltd., Heaton Works, Newcastle upon Tyne, 6.

Edward Wood and Co., Ltd., 68, Victoria Street, London, S.W.1.

The Brush Group, Ltd., Duke Street, St. James's, London, S.W.1.

Le Tourneau-Westinghouse Company, Peoria, Illinois, U.S.A.

Allgemeine Elektricitats-Gesellschaft, Frankfurt (Main)-Sud 10.

Swedish Lloyd, Marlow House, Lloyd's Avenue, London, E.C.3.

Bakelite, Ltd., 12–18, Grosvenor Gardens, London, S.W.1.

The Hunslet Engine Company, Ltd., Jack Lane, Leeds, 10.

Richard Klinger, Ltd., Klingerit Works, Sidcup, Kent.

The D.P. Battery Company, Ltd., Bakewell, Derbyshire.

G. Wimpey and Co., Ltd., Hammersmith, London, W.6.

Coventry Gauge and Tool Company, Ltd., Coventry.

A.C.V. Sales, Ltd., 49, Berkeley Square, London, W.1.

Taylor Woodrow, Ltd., 10, Park Street, London, W.1.

Tube Investments, Ltd., The Adelphi, London, W.C.2.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

Mon., Jan. 9th.—Central London Branch : St. Ermins Hotel, Caxton Street, S.W.1, Exhibition Film, 7 p.m.——Leeds Branch : Great Northern Hotel, Leeds, "Power Cable Manufacture and Design," N. Hewett, 7.30 p.m.——N.W. London Branch : Century Hotel, Forty Avenue, Wembley Park, "Power Factor Correction," F. Guess, 8.15 p.m.——Sheffield Branch : Royal Victoria Station Hotel, Sheffield, "Modern Telephony," C. E. Hay, 7.30 p.m.

Tues., Jan. 10th.—Bournemouth Branch : Grand Hotel, Firvale Road, Bournemouth, "Installation Testing," S. Potter ; "Meters and Metering," H. F. Miles, 8 p.m.——Luton Branch : Midland Hotel, Williamson Street, Luton, "Electronic Motor Control," Ch. Coates, 8 p.m.

Wed., Jan. 11th.—Birmingham Branch : Room 3, Chamber of Commerce, New Street, Birmingham, Discussion of Association and Exhibition Matters, 6.30 p.m.——Halifax Branch : Crown Hotel, Horton Street, Halifax, "Power Factor Correction," A. Brecknell, 7.30 p.m.——S.W. London Branch : Guild House, 32, Worple Road, Wimbledon, "Incentives and Production Bonuses," E. A. Langsdon ; "The Flying Paster," R. J. O'Hara, 8.15 p.m.

Fri., Jan. 13th.—Stoke and Crewe Branch : Royal Hotel, Crewe, "Heating and Ventilating," 8 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., Jan. 11th.—N.E. Section : Institution of Mining and Mechanical Engineers, Neville Hall, Westgate Road, Newcastle upon Tyne, "Some Interference Problems Associated with the Television Service," J. C. Belcher, 6 p.m.——W. Midlands Section : Technical College, Wulfruna Street, Wolverhampton, "Computer Control of Machine Tools," H. Ogden, 7.15 p.m.

Thurs., Jan. 12th.—Scottish Section : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Peaceful Uses of Atomic Energy," K. G. McNeill, 7 p.m.

BRITISH WELDING RESEARCH ASSOCIATION

Thurs. and Fri., Jan. 12th and 13th.—Institution of Electrical Engineers, Savoy Place, London, W.C.2. Thursday, "The Problem of Productivity Improvement in Welded Production," A. G. Thompson, 9.30 to 11 a.m.; "Recent Developments in Welding Steel, A. R. Muir, 11.30 a.m. to 1 p.m.; "Developments in Non-Destructive Testing," H. L. Carson and B. R. Byrne, 2.30 to 3.30 p.m.; "Developments in Non-Destructive Testing," H. L. Carson and B. R. Byrne, 4 to 5 p.m.; Friday, "What Can Be Done to Reduce Fatigue Failure and Brittle Fracture ?" R. Weck, 9.30 to 11 a.m.; "Resistance Welding Ferrous and Non-Ferrous Metals," E. V. Beatson, 11.30 a.m. to 1 p.m.; "Processes for Welding Light Alloys," W. G. Hull, 2.30 to 3.30 p.m.; "Metallurgical Aspects of Welding Light Alloys," P. T. Houldcroft, 4 to 5 p.m.

ILLUMINATING ENGINEERING SOCIETY

Mon., Jan. 9th.—Leeds Centre : Yorkshire Electricity Board, Ferensway, Hull, "Street Lighting," J. J. French, 7 p.m.

Tues., Jan. 10th.—Royal Society of Arts, John Adam Street, London, W.C.2, "Recent Developments in Photometry and Colorimetry," G. T. Winch, 6 p.m.

Wed., Jan. 11th.—Edinburgh Centre : Y.M.C.A. Hall, 14, St. Andrews Street, Edinburgh, 2, "The Lighting Engineer," G. E. L. Comrie, 6.15 p.m.

INCORPORATED PLANT ENGINEERS

Mon., Jan. 9th.—Dundee Branch : Mathers Hotel, Dundee, "Hospital Services," C. N. Anderson, 7.30 p.m.

Tues., Jan. 10th.—Edinburgh Branch : 25, Charlotte Square, Edinburgh, "Materials Handling," J. Findlay, 7 p.m.——Manchester Branch : Engineers' Club, Albert Square, Manchester, "Power Factor Correction," 7.15 p.m.

Wed., Jan. 11th.—Leicester Branch : College of Art and Technology, The Newarkes, Leicester, "Rust Prevention," 6.30 p.m.——Western Branch : Grand Hotel, Bristol, "Works Engineering Organisation," 7.15 p.m.

Thurs., Jan. 12th.—Glasgow Branch : Scottish Building Centre, 425–427, Sauchiehall Street, Glasgow, "Some Factors Concerning Works Capital Expenditure," F. Franklin, 7 p.m.——Merseyside and N. Wales Branch : Royal Institution, Colquitt Street, Liverpool, "Radiography in Industry," E. J. Grimwade, 7.15 p.m.——N.E. Branch : Roadway House, Oxford Street, Newcastle upon Tyne, "The Gas Turbine in Industry," J. R. Needham, 7 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Sat., Jan. 7th.—W. Riding of Yorkshire Branch : Technical College, Bradford, "The Use of Refractories in the Foundry," W. E. Ambler, 6.30 p.m.

Mon., Jan. 9th.—Lancashire Branch : Midland Hotel, Manchester, "Practical Simple Costing in the Foundry," G. Judd, 7 p.m.——Sheffield Branch : College of Technology, Pond Street, Sheffield, "Dust Control in Foundries," C. M. Stoch, 7.15 p.m.

Thurs., Jan. 12th.—Lincolnshire Branch : Technical College, Lincoln, "Foundry Developments," D. Killingworth, 7.15 p.m.——Southampton Section : Technical College, St. Mary's Street, Southampton, Technical Films, 7.30 p.m.

Fri., Jan. 13th.—Tees-Side Branch : Teesdale Hall, Head, Wrightson and Co., Ltd., Thornaby-on-Tees, "Pattern Equipment—Present-day Trends and the Future of the Patternmaking Craftsmen," L. Brown, 7.30 p.m.

INSTITUTE OF FUEL

Mon., Jan. 9th.—N.E. Section : Chemistry Lecture Theatre, King's College, Newcastle upon Tyne, Four Short Papers, "Case Histories," by the National Industrial Fuel Efficiency Service, 6.30 p.m.

INSTITUTE OF PETROLEUM

Tues., Jan. 10th.—26, Portland Place, London, W.1, "Petroleum Fuels for Domestic Heating and Lighting," G. F. J. Murray and D. F. Tomkins, 5.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Mon., Jan. 9th.—Scottish Centre : Institution of Engineers and Shipbuilders, Elmbank Crescent, Glasgow, "Gas Turbines and Their Application to Road Transport," A. Enticknap, 7.30 p.m

Tues., Jan. 10th.—Eastern Centre : Lion Hotel, Cambridge, "Some Aspects of Vehicle Insurance and Accident Assessment," L. F. Simmons, 7 p.m.——Western Centre : Royal Hotel, Bristol, "The Commer 'T.S.3' Two-Stroke Diesel Engine," E. W. Coy, 7.30 p.m.——N. Regional Centre : Victoria and Station Hotel, Preston, "Thin Wall Bearings," P. T. Holligan 7.30 p.m.——W. Regional Centre : Adelphi Hotel, Lime Street, Liverpool, "Gas Turbines and Their Application to Road Transport," A. Enticknap, 7.30 p.m.

Fri., Jan. 13th.—S. Wales Group : S. Wales Institute of Engineers, Park Place, Cardiff, "The Development of the Gas Turbine for Road Transport," P. A. Phillips, 7 p.m.

INSTITUTE OF WELDING

Mon., Jan. 9th.—S.W. Branch : Radiant House, Pipe Lane, Bristol, Welding Forum, 7.15 p.m.

Tues., Jan. 10th.—Liverpool Branch : The University, Liverpool, "Photoelasticity," W. J. Kearton, 7.15 p.m.

Wed., Jan. 11th.—Preston Branch : Technical College, Corporation Street, Preston, "Welding of Chains," W. G. Biggart, 7.15 p.m.——S. London (Medway Section) : Sun Hotel, Chatham, "Through the Welding Arc," W. K. B. Marshall, 7.45 p.m.

Thurs., Jan. 12th.—S. London Branch : 2, Savoy Hill, London, W.C.2, "Tubular Steel Design," R. G. Taylor, 6.30 p.m.

Fri., Jan. 13th.—E. Midlands Branch : College of Art, Derby, "Modern Techniques for Welding Aluminium and its Alloys," J. E. Tomlinson, 7.15 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Jan. 10th.—Railway Meeting : Great George Street, Westminster, London, S.W.1, "Consolidation of Ballast," I. G. White, 5.30 p.m.

Wed., Jan. 11th.—N.W. Association : Picton Hall, William Brown Street, Liverpool, 3, "Recent Developments in Prestressed Concrete," S. C. C. Bate, 7.30 p.m.

Thurs., Jan. 12th.—Great George Street, London, S.W.1, "The Roofing of Cleadon Reservoir," N. J. Ruffle and H. Tottenham, 5.30 p.m.——N.W. Association : Reynold's Hall, College of Technology, Manchester, "Space Frames and Skin Structure," F. J. Samuely, 6.30 p.m.——Midlands Association : James Watt Memorial Institute, Great Charles Street, Birmingham, "Prestressed Concrete as Applied to Building Frames," Francis Walley and H. C. Adams, 6 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

To-day, Jan. 6th.—Joint Meeting : Institution of Mechanical Engineers, 1, Birdcage Walk, London, S.W.1, "Power Station Auxiliary Plant," G. F. Kennedy and F. J. Hutchinson, 5.30 p.m.

Mon., Jan. 9th.—Informal Meeting : Savoy Place, London, W.C.2, Discussion on "The Efficient Use of Technical Personnel," opened by the President, 5.30 p.m.

Tues., Jan. 10th.—Education Discussion Circle : Savoy Place, London, W.C.2, Discussion on "Teaching Electrical Engineering to Mechanical Engineering Students," opened by H. E. Dance, 6 p.m.——London Graduates' and Students' Section : Public Library, Chelmsford, "An Introduction to the Transistor," A. V. Bryant, 7 p.m.

Wed., Jan. 11th.—Radio and Telecommunication Section : Savoy Place, London, W.C.2, "Pulse-Time-Modulation Terminals for Music Transmission Over Radio Links," R. F. Rous, 5.30 p.m.

INSTITUTION OF ENGINEERING DESIGNERS

Mon., Jan. 9th.—Northern Architectural Association Hall, 6, Higham Place, Newcastle upon Tyne, "Thrust and Journal Bearings with Film Lubrication," A. F. Wilson, 7.15 p.m.

INSTITUTION OF ENGINEERING INSPECTION

Wed., Jan. 11th.—Royal Society of Arts, John Adam Street, London, W.C.1, "Testing Gear for Inspection of Services Electronic Equipment," 6.45 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., Jan. 10th.—39, Elmbank Crescent, Glasgow, C.2, "Cargo Handling Appliances," L. T. Morton, 7.30 p.m.

INSTITUTION OF ENGINEERS-IN-CHARGE

Wed., Jan. 11th.—St. Bride Institute, Bride Lane, Fleet Street, London, E.C.4, "Working Environments and Accident Prevention," B. A. Inshaw, 6.30 p.m.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS

Tues., Jan. 10th.—S.W. Branch : G.E.C. Building, Cardiff, "Thermal Insulation of Plant and Buildings," Philip E. Millington, 6.30 p.m.

Wed., Jan. 11th.—Sessional Meeting : Institution of Mechanical Engineers, 1, Birdcage Walk, London, S.W.1, "Small-Pipe, Forced-Circulation Central Heating," S. A. Burke, 6 p.m.

Thurs., Jan. 12th.—Liverpool and District Branch : College of Buildings, Clarence Street, Liverpool, "Oil Burners for Small Boilers," G. L. Barker, 6.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Jan. 6th.—Joint Meeting with the Institution of Electrical Engineers : 1, Birdcage Walk, Westminster, London, S.W.1, "Power Station Auxiliary Plant," G. F. Kennedy and F. J. Hutchinson, 5.30 p.m.

Mon., Jan. 9th.—N.E. Branch : Stephenson Building, King's College, Newcastle upon Tyne, 2, Annual General Meeting, 6.15 p.m.

Tues., Jan. 10th.—Automobile Division : 1, Birdcage Walk, London, S.W.1, "Overdrives and Their Control," S. H. Ashby, 5.30 p.m.——E. Midlands Branch : College of Technology, Leicester, Annual General Meeting, "The Properties of Matter at High Pressure," D. M. Nevitt, 6.30 p.m.——Yorkshire Graduates' Section : Lecture Theatre, The University, Sheffield, "Engineering Maintenance," W. O. Kirkwood, 6.30 p.m.

Thurs., Jan. 12th.—Internal Combustion Engine Group Discussion : 1, Birdcage Walk, London, S.W.1, "Will High-Pressure Supercharging Maintain the Lead of Four-Stroke Diesel Engines Over Two-Stroke Diesel Engines ?" 6.45 p.m.——Industrial Administration and Engineering Production Group Meeting : Engineers' Club, Albert Square, Manchester, "The Application of Electronic Instruments to Mechanical Engineering," R. B. Sims and P. Briggs, 6.45 p.m.

Fri., Jan. 13th.—General Meeting, Hydraulics Group : 1, Birdcage Walk, London, S.W.1, "Water-Ring Self-Priming Pumps," E. Crewdson, 5.30 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Mon., Jan. 9th.—Sheffield Section : Grand Hotel, Sheffield, "Health in Industry," B. P. R. Hartley, 6.30 p.m.——Yorkshire Section : Hotel Metropole, King Street, Leeds, 1, "Automatic Inspection—The Anatomy of Conscious Machines," J. A. Sargrove, 7 p.m.

Tues., Jan. 10th.—Coventry Section : Craven Arms, High Street, Coventry, "Production of Piston Rings," H. C. Blackford, 7 p.m.——Oxford Section : Town Hall, Oxford, "Production by Electronics," E. R. Davies, 7.15 p.m.

Wed., Jan. 11th.—Liverpool Section : Exchange Hotel, Liverpool, "Die Castings," 7.30 p.m.——Edinburgh Section : North British Station Hotel, Edinburgh, "Nothing Like Leather," J. G. Osborne, 7.30 p.m.——London Graduate Section : 10, Chesterfield Street, W.1, "Functions of Works Cost Accounting," B. Gateshill, 7.15 p.m.

Thurs., Jan. 12th.—Luton Graduate Section : Hatfield Technical College, Hatfield, "Management and Production Problems in the Aircraft Industry," J. V. Connelly, 7.45 p.m.——Rochester Section : Sun Hotel, Chatham, "Electronic Control in Industry," E. Heys, 7.30 p.m.

Fri., Jan. 13th.—Eastern Counties Section : Diocesan Hall, Tower Street, Ipswich, "Factory Electrical Layout and the Production Engineer," C. A. Marriott ; "A Special Tapping Machine," L. A. Childs ; "Flaw Detector," E. J. Cove, 7.30 p.m.——W. Wales Section : Central Library, Alexandra Road, Swansea, "Electronics for Production," J. A. Sargrove, 7.30 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Tues., Jan. 10th.—Lancashire and Cheshire Branch : The University, Liverpool, "Photoelasticity," W. J. Kearton 6.30 p.m.

Wed., Jan. 11th.—Northern Counties Branch : Cleveland Scientific and Technical Institution, Middlesbrough, "The Civil Engineer and Britain's Atomic Factories," D. R. R. Dick, 6.30 p.m.——Yorkshire Branch : Blue Bell Hotel, Scunthorpe, "Brittle Fracture Problems in Steel Construction," G. M. Boyd, 6.30 p.m.

Thurs., Jan. 12th.—11, Upper Belgrave Street, London, S.W.1, "The Application of an Electronic Digital Computer to Some Problems of Structural Analysis," R. K. Livesley, 6.30 p.m.——Lancashire and Cheshire Branch : College of Technology, Manchester, "Space Frames and Skin Structures," Felix J. Samuely, 6.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Jan. 6th.—Film Evening : Pepys House, 14, Rochester Row, London, S.W.1, "T.L.B. Metal Powder Deposition Process," introduced by E. Wallace ; and "Please Pass the Condensate," E. E. Bastick, 7 p.m.

Mon., Jan. 9th.—Sheffield and District Section : Livesey Clegg House, Sheffield, "The Factory Act," D. E. Jones, 7.30 p.m.

Fri., Jan. 13th.—Ordinary Meeting : Pepys House, 14, Rochester Row, London, S.W.1, "High-Altitude Passenger Flying with Special Reference to Air Treatment," Barry T. Turner, 7 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

To-day, Jan. 6th.—Engineers' Club, Albert Square, Manchester, "Polythene and its Uses," A. Renfrew, 6.45 p.m.

NEWCOMEN SOCIETY

Wed., Jan. 11th.—Ordinary General Meeting : Iron and Steel Institute, 4, Grosvenor Gardens, London, S.W.1, "The Continental Origins of the Man-Engine and its Development in Cornwall and the Isle of Man," David H. Tew, 5.30 p.m.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Fri., Jan. 13th.—Mining Institute, Newcastle upon Tyne, "The Modern Manufacture of Steel Plate for Shipbuilding," T. F. Pearson, 6.15 p.m.

ROYAL AERONAUTICAL SOCIETY

Tues., Jan. 10th.—Section Lecture : 4, Hamilton Place, London, W.1, "Some Modern Structural Problems," W. S. Hemp, 7 p.m.

Thurs., Jan. 12th.—Royal Institution, Albemarle Street, London, W.1, Presidential Address, N. E. Rowe, 6 p.m.

ROYAL SOCIETY FOR THE PROMOTION OF HEALTH

Wed., Jan. 11th.—London Sessional Meeting : Caxton Hall, London, S.W.1, "The Housing Repairs and Rents Act," J. Clancey, 10.30 a.m.; "Slum Clearance," D. J. E. Lamb ; "Grants for Improvements and Conversions," J. E. Austin, 2 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

Thurs., Jan. 12th.—Manson House, 26, Portland Place, London, W.1, "Liquid Flow Control," B. W. Balls, 6.30 p.m.

TECHNICAL PUBLICATIONS ASSOCIATION

Tues., Jan. 10th.—Electrical Engineering Lecture Room, University College, Gower Street, London, W.C.1, "Illustrations for Technical Documents," C. Baker, 7.30 p.m.

WEST OF SCOTLAND IRON AND STEEL INSTITUTE

Fri., Jan. 13th.—39, Elmbank Crescent, Glasgow, "Notes on Basic Open-Hearth Melting Shop Practice," J. Gibson, 6.45 p.m.